ENGINEERING

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e Shop Floor

sailing on a lubricant...

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Fission and Fusion

NO-ONE knows as yet what will be the outcome of thermonuclear studies at Harwell and elsewhere. Commercial thermonuclear power is now believed to be a long-term probability, but what effect its advent may have on the development of fission reactors, and when this effect is likely to be felt, remains obscure. The possibility that the days of the fission reactor may be numbered is one that must be giving many cause for thought and one that certainly needs airing; but it is a matter of such gravity, that superficial speculation may well be hazardous. Without careful handling, the uneasiness that is currently troubling American nuclear industry may spread to Britain.

Sir John Cockcroft has stated categorically that official thinking on fission reactors has not been altered by the successful thermonuclear experiments. No doubt the Atomic Energy Authority have long been familiar with the possibility of a conflict in the distribution of resources between fission and fusion work, so that the successful experiments have given no reason for a change in attitude. Existing plans almost certainly make due allowance for the long-term consequences of thermonuclear power, and statements in Parliament have confirmed that no modifications in the British nuclear power programme are envisaged.

But unless the situation is fully clarified, speculation is likely to continue—speculation that may weaken the confidence of those working or investing in this field. Recruitment, too, may suffer without substantial reassurance. It is almost certain to be noted that from the discovery of fission to the completion of the first full-scale power reactor was less than 20 years, notwithstanding that during much of that time no large-scale nuclear research organisations existed, and that attention was largely directed to military applications. Now, on the other hand, we have broadly based establishments, staffed with experienced personnel and equipped with advanced experimental apparatus that for early fission work was not available. Lord Mills has stated in the House of Lords that it took 18 years to produce the Calder Hall station. Using the same assumption, might it not be said with equal truth that thermonuclear development has been in progress for 26?

Finally, in research, success breeds success, since a set of favourable results presented strikingly to the public make it easier for the Government to allocate financial resources to the project. The rate of advance may thus be exponential.

Nevertheless, when Sir John Cockcroft says that the first commercial fusion reactor may be more than 20 or 30 years away, he is speaking on the basis of the best available information, with a full awareness of the points made above and many others. But whether public estimates tend towards the optimistic or pessimistic limit of private thinking it is difficult to say.

Without a clear and detailed statement of policy and the reasoning that underlies it, there is bound to be uncertainty. It should be emphasised that many of those affected and many responsible for making relevant decisions are not intimately familiar with nuclear developments. Engineering firms must constantly be planning for the future, and hesitation may seriously affect their current work. Investment programmes may only be concerned with the next 15 years, but a man's career may last as long as 40.

One answer might be as follows. Whatever success may attend the thermonuclear experiments, it is most unlikely that a competitive fusion reactor will be built within 10 years. For the succeeding 10 years, since fuel is likely to be a negligible fraction of the cost of power to the consumer, and since the capital cost of thermonuclear reactors may well be high, it will be immaterial from a financial point of view whether fission or fusion reactors provide the basis of our nuclear power programme. The essential task is to provide ourselves with an adequate substitute for our depleted or expensive coal and oil resources. Thus, we could safely commit ourselves to a fission reactor programme lasting a minimum of 20 years, with thermonuclear work limited to prototype studies. If this were guaranteed, with adequate provisos to cover the most exceptional discoveries, full benefit from existing investment might be assured. Development of the fission reactor could then proceed in confidence and Britain be certain of economic power whether or not the thermonuclear reactor proved successful.

Even success in thermonuclear development may not exclude the fission reactor. Fission and fusion, at least in the initial stages, may well be complementary, both being necessary for a properly integrated nuclear power programme.

The danger, however, is that Britain may fall between two stools, without sufficient energy supplies from fission or fusion. Or like the dog who, seeing the bone he carries in his mouth reflected in a stream, we may pursue the more attractive but remoter prize and lose the one we have.

Cover Picture. *An engineer walking round a workshop might look at the contents of these boxes to make a spot-check or for various technical reasons. Nurnberg the photographer looks at the pattern they create.*

* * *

Plain Words

I am exasperated by the craftsman (he doesn't deserve the title) who cannot think for himself. You know the type well enough: he is passably good at replacing defective parts with new ones from the store, but if the correct spare is not available he is flummoxed. He's a poor successor to the old-time millwright. I remember a foreman millwright who had almost magical powers for getting round the insuperable. On one occasion during the last war, when steel wire rope was practically unobtainable, some vital tipping gear was out of service because the rope had broken and frayed in several places, and everyone, from the works manager down, saw no way out of the difficulty without a new length of rope. The foreman millwright was brought into the discussion. It was clear from his expression that he could see our difficulty, but he didn't commit himself either way. Next morning he came up with the answer—a beautifully simple one too, though for the life of me I can't remember it.

Of course, we have only ourselves to blame. The more we mechanise production and eliminate the human factor, the less scope there is for the exercise of common sense and imagination. And the fewer fitters there are who have to work things out for themselves the less chance there is of some good ones being thrown up. The same kind of thing happens in other walks of life. In sport, for example, a nation which sees that many schoolboys and schoolgirls have ample opportunity for sport stands a much better chance of producing Olympic winners than those where few are encouraged to take up sport. In engineering the demise of versatile craftsmen would be doubly tragic because the future professional engineer can learn a lot from them during his apprenticeship. You cannot learn much from a mass-production "operative"—except something about the psychology of introspection.

Perhaps I am wrong in assuming that this is the whole picture. Maybe the truth is that, with the growth of computers and other extensions of human powers, mental as well as physical, there is a corresponding increase in the demand for craftsmen who can exercise skill and imagination in specialised fields. At one time a good fitter could readily switch from, say, locomotives to ships or motor-cars. To-day, perhaps individual skills are not as universally applicable. What we shall want in the future is a method of ascertaining the abilities and qualities in a craftsman which are suited to each specialised craft. Management selection we know about: craftsman selection may be the thing of the future.

But I still wish my garage had one of the old-style fitters.

CAPRICORN

Weekly Survey

Designer on the Shop Floor

To-day, the designer of equipment has many factors to take into account as well as the immediate technical efficiency of machinery. For example, in compliance with an Order laid before Parliament last week in accordance with the Clean Air Act, 1956, it becomes an offence after June 1 to emit dark smoke from chimneys. This involves a reduction in the emission of grit and dust (for dark smoke is a factory rather than a house problem). After that date all new furnaces installed to burn pulverised fuel or more than one ton per hour of other solid fuels will have to be equipped with grit and dust arresting plant.

There is a growing appreciation, too, that equipment must be designed with regard to the human element in factories as well as to take into account public amenities. The designer has been often criticised, not least in engineering, for living in an ivory tower and designing equipment without due regard to its production on the shop floor. One of the big contributions which work study is making these days to increasing efficiency is to make the production requirements on the shop floor known to the designer before he begins to work on the drawing board. This does not mean that the designer should be at the mercy of the production department but that he should work in collaboration with it. The Engineering and Allied Employers' West of England Association is offering a new course called "Designing Equipment for Human Use" at Bristol in May for a two-weeks period. The object of the course is to induce equipment designers to take into account not only the characteristics of machines but those of their operators. This attempt to promote the study of ergonomics, that is, the study of the interaction of men and their environment (now usually with special reference to the machine environment) deserves every success.

Introducing Electrification

The twenty-ninth in the series of Faraday lectures organised by the Institution of Electrical Engineers has been marked by tragedy, for Mr. G. H. Fletcher who prepared the material died before he was able to complete the series of presentations. So in London the lecture was actually given by Mr. R. Ledger who had worked with Mr. Fletcher in the preparation. The subject chosen was "The Electrification of Railways" and, as usual in this series, it was dealt with in a manner to appeal to younger folk.

Mr. Ledger outlined the main proposals for electrification in this country, and pointed out how technical advances, particularly in the fields of rectification and insulation, had made the use of alternating current at 25 kV a practical proposition. He drew attention to the saving possible with this method, instancing that only 12 substations would be needed on a stretch of line that would require 70 if the supply were at 1,500 V direct current. Other savings were in copper and generation efficiency. The arrangement of gear in a locomotive was shown by a one-eighth scale model which had alternative machinery compartments representing direct current, alternating current and Diesel-electric plant. This brought out the problem of train heating which, said Mr. Ledger, would require an additional 160 h.p. under normal conditions for a 12 coach train using electric heaters—a figure which could well be doubled under extremes of temperature.

Drawing a comparison with steam locomotives, Mr. Ledger showed by models where the heat from 100 lb. of coal went. In the case of the steam engine, only the energy from 9 lb. was left to haul the train, whereas with electricity that from 26½ lb. was available. These figures indicated a possible saving of about a million tons of best quality coal per annum—about the same saving as from 10 atomic power stations of the present size. Running costs would be reduced about 50 per cent. and the number of locomotives by about one-third. As an example of the improved working that could be obtained, a short film of the Manchester-Sheffield line was shown; in a 24 hour period an electric locomotive worked goods traffic over 288 miles as against 100 for a steam one. This resulted in a saving of 105 crews—equivalent to 315 men.

Signalling is another big field in which electrification plays a part. With the aid of the locomotive model already mentioned, and examples of actual equipment, Mr. Ledger showed the working of the automatic train control system that has been adopted by British Railways. He took care to emphasise, however, that the final responsibility still rested with the driver, who had the power to cancel the warning—a power necessary in order to maintain proper running of trains.

Rail Lesson from America

A reminder that modernisation of railway equipment needs to be supported by other inducements to the customer is contained in an article in *British Transport Review* for December on "The Current American Railroad Scene," by Mr. H. R. Gomersall, Planning Officer (Reconstruction), Eastern Region, British Railways. American experience so far with new types of passenger rolling stock, such as the Talgo trains and "Train X" does not suggest that novelty in accommodation will win back passengers from the private car, and although economies in construction and operation are expected from experiments of this kind, it is unlikely that further similar trains will follow the prototypes. Previous optimism over a new conception of railway passenger vehicles seems to have given place to the realisation that "cheaper travel is about the only general means of competing for passenger custom." Already more than a quarter of the 113 Class I railroads in the United States operate freight only, and although others have reduced or reorganised passenger services, no action taken so far has arrested the downward trend in traffic. "Air travel has sounded the death knell of many once profitable trains," says Mr. Gomersall, and British Railways may well reflect to-day on the number of business travellers who now make the return trip between London and Glasgow in a day by air in preference to spending the best part of two working days in trains and at least one night at an hotel.

Evidence of increased numbers of passengers on British railway services comes mainly from short- or medium-distance routes operated by Diesel railcars, or from recent electrifications such as Liverpool Street to Southend, but the effect on net revenue has still to be seen. Various technical improvements in the operation of freight traffic in the United States have reduced working expenses appreciably, but there is still a drift to the road. Mr. Gomersall describes the "piggy-back" services which have been introduced for conveying road trailers on rail wagons, and a "railvan" experiment by the Chesapeake and Ohio with a vehicle able to run on rail or road. Containers, which achieve the same result of combining rapid transit of bulk loads by rail over long distances combined with door-to-door service, are not being used to any extent, mainly, the author suggests, because of the specialised handling equipment required, restrictions on the size and weight of containers, and an apparent reluctance to tackle the rates problem. Mr. Gomersall hopes that this survey of problems across the Atlantic may stimulate

suggestions for meeting a similar situation here. His article is a warning against being mesmerised by reiteration of the words "modernisation plan" into assuming that this is a comprehensive insurance against the ills now menacing railways everywhere.

Using Transport Wisely

Private cars parked for hours daily on some of the most expensive land in our cities, and suburban trains doing no more than 10 or 15 hours' useful work a week, were among the anomalies of the present-day transport scene discussed in a paper on "The Future Pattern of Surface Transport," presented to the Town and Country Planning Summer School at Oxford last autumn by Mr. A. J. White, Assistant General Manager, Eastern Region, British Railways. Extracts from the paper reproduced in the December issue of *British Transport Review* express the hope that new Diesel and electric train services may draw off some bus and coach business, although the author holds the view that a substantial mileage of railway still open should and will be closed.

Faster freight trains, in growing numbers, he believes, may win a fair share of their proper business, which is to carry heavy bulk loads between railheads, leaving deliveries to road transport and perhaps offering a growing proportion of door-to-door service by means of containers and demountable bodies. If common sense leads to such collaboration between rail and road haulage, the standard of service provided may persuade some firms at present using their own transport to turn to the public undertakings.

The private motorist may be less amenable to reason, and Mr. White foresees the need for some restrictions, such as prohibition of parking over large areas in cities, if the present congestion is to be relieved. In London the cars which cause the trouble carry less than one tenth of the people who travel up daily to work, but the road space occupied has reduced the speed of buses in the central area until the contribution of the bus fleet to mass movement is far less than it could be.

Suburban railway peak problems could be eased by more New Towns, but only if they are sufficiently far removed from existing large centres of population. One New Town some 20 miles from London contributes about a thousand peak-hour travellers from a population of 28,000. A policy attractive to the railways is that of expanding country towns, for most of these are on lines which are not at present used to capacity.

As an example of the judicious use of rail and road facilities for passenger transport, Mr. White quotes the example of Holland, where passenger services have been withdrawn from over 20 per cent. of the railway network and two-thirds of all the stations in the country have been closed. The remaining railway facilities are excellent and the bus operators have consolidated their services. Here the ratio of railway operating expenses to receipts is the best in Europe, and the Dutch seem to him to have shown the way which we must follow.

More Scholarships . . .

The engineering industry is increasingly offering facilities for able school leavers to take up a career in engineering. It is all to the good that there should be signs of activity in this respect at the present time. In the first place it shows that engineering companies are prepared to follow a policy of enlightened self-interest in attracting increasing numbers of young men into engineering as a career. It also keeps before the public the urgency of increasing the supply of technicians and shows that industry itself is doing something active about it.

Even within the last week there have been a number of significant announcements about engineering scholarships. The Junior Institution of Engineers and the Maudslay Society have issued the rules for the Maudslay scholarships and prizes for 1958. Guest Keen and Nettlefolds Limited has announced that it is offering three university scholarships each year to boys who might not otherwise be able to take up a university place.

The scheme takes its place among several, which have been announced by other leading companies and engineering organisations to help boys whose parents are severely handicapped in sending their children to universities by the application of a means test. Guest Keen and Nettlefolds are to pay students' fees and their maintenance and other expenses will be paid as a salary subject to deduction of income tax and National Health Insurance, the students ranking as employees of the company. Students will work during their long vacations either with the group companies in this country or with certain recognised companies abroad.

An ambitious scheme has also been announced by the English Electric Company, Limited. This is in addition to the extensive craft, technical and student apprenticeship schemes already run by this company. The new scheme is for 20 scholarships a year to be made available to boys leaving school or completing National Service who wish to become engineers or technologists.

During their university residence, undergraduates will receive £450 a year tenable for three years at any United Kingdom university beginning in the academic year 1958/59. Scholarships can be held for engineering, applied science, mathematics or any technology related to engineering. The scholarships are free from any means test whatsoever. This scholarship scheme falls into three parts—university residence, industrial training, and staff appointing—and it is hoped that scholars will stay in their jobs at least for the minimum period necessary for corporate membership of the appropriate professional institution. No conditions of service with the English Electric group are attached to the scholarships.

. . . And Fellowships

To emphasise further its decision to consider technical training as a form of investment, English Electric has now published information about a fellowship scheme which has been operating with the universities since 1957. The English Electric Industrial Fellowships Scheme offers two years post-graduate training in engineering, management and production at a salary of £750 a year for honours graduates with the necessary qualifications.

Four fellowships were given for 1957 and the scheme has been so successful in the company's opinion that it has decided to offer twelve in 1958. The object of these fellowships is to give special training for young men who are considered to be capable of becoming engineer administrators for top-level organisation, planning and control. In other words it can be viewed, to judge from the outside, as a plan to bring forward able young technicians to fairly senior managerial posts by an intensified course at the post-graduate stage. Speaking in London last week when the announcements were made, the head of the group's Technical Personnel Administration emphasised that a recent survey of management level posts in English Electric showed that over 60 per cent. were held by ex-apprentices and that this percentage is likely to increase.

The group can foresee no likelihood of saturation and considers that it will need more and more able men to take responsible posts while they are still young. "As you know," he said, "it is not unusual for men to be appointed chief engineer, divisional commercial manager, works manager in their early 30's. I think this tendency will continue."

Letters to the Editor

THE GUILD AND THE PROFESSION

SIR, An item about the annual report of the Metropolitan Water Board, on page 191 of your issue of February 7, makes the point that "An innocent scanning the report might well be led to believe that such a triumph over nature was achieved without a single engineer." Unfortunately, there is no reason why members of the profession should expect the public to be other than innocents in such matters, unless they take action collectively to ensure that their responsibilities are understood. The report in question is not exceptional if it fails to do this.

As part of its current programme, the Guild determined in 1957 to prepare and carry out a public relations programme designed:

(*a*) to increase public awareness of the work and responsibilities of the professional engineer and of his fundamental importance in the economy of the country; and

(*b*) to encourage proper acknowledgment of the part played by the professional engineers concerned, wherever references are made to engineering undertakings.

Possibly the greatest need of the engineering profession to-day is to instil proper appreciation of its work into the mind of the general public, but such a task can only be carried out satisfactorily if members of the profession give it their support. The Guild is at present in the position of having to attempt to carry out a series of vitally important tasks on behalf of the engineering profession, with the active support of only a small percentage of its membership. In these circumstances, it will be no use complaining if the Guild fails to take full advantage of the present favourable climate of opinion towards the engineer, and if his status remains inadequate in consequence. In a letter which you were good enough to publish (August 9, 1957, page 165), dealing with the new programme and, in particular, the survey of salaries and public relations activities, I wrote: "but these are costly undertakings and it would be unwise as well as unfair if those at present outside the Guild were to rest content with their position, in the comfortable assurance that the present members would see them through." I hope that your remarks will serve to emphasise both the urgency and the practical importance of what the Guild is trying to do, and that members of the profession will enable the Guild to complete its task by giving it their support here and now.

Yours faithfully,
J. G. ORR,
Secretary.

The Engineers' Guild,
78 Buckingham-gate,
London, S.W.1.
February 17, 1958.

RAILWAY COACH VIBRATIONS

SIR, I was interested to read your review on February 7 (page 186) of the paper which I gave recently to the Institution of Locomotive Engineers, and was particularly interested in the criticisms.

I note your suggestion that the numerical results would carry more weight if they had been based on a single series of curves obtained under British conditions: but I do not see why human beings in Britain should, on the whole, react to vibrations differently from human beings in France or Germany. Meanwhile, the Mauzin-Sperling curves and method of assessing the riding of vehicles have been adopted by most railway administrations in Western Europe —and that, in itself, is a big point in favour of our adopting them so that we can produce results which can be compared with results obtained on the Continent. It is true that it is difficult to express physiological reactions in terms of mathematics, but my experience is that it is easier

Continuing Letters to the Editor

to get acceptable consistency of test results when conditions to which the persons are subjected are uniform, rather than continually changing, as in the case of the transition curve which you mention.

Until recently, it has been difficult to express the riding of a vehicle quantitatively yet easily. Your suggestion that a figure such as the mean acceleration would be of value could be very misleading, because the frequency of the accelerations would not have been considered: it can affect the answer by 100 per cent. or even more. It may be that someone in the future will find justification for suggesting a refinement to the method, but in the meantime I am of the opinion that we are very near the truth—and certainly much of the information being obtained from the test results is proving valuable.

Yours faithfully,
J. C. LOACH,
Superintendent,
Vehicle and Track Division.

Research Department,
British Railways Division,
British Transport Commission,
55 Ashbourne-road,
Derby.
February 15, 1958.

Obituary

MR. W. B. CHALLEN

We record with regret the death, on February 11, at the age of 92, of Mr. Walter Bernard Challen, chairman and managing director of Taylor and Challen, Limited, Derwent Works, Birmingham, 19. Bernard Challen—he was always known by his middle name—was born in Birmingham on July 11, 1866, the son of S. W. Challen, and was educated at King Edward's School and Mason College, Birmingham. His early engineering training was received as an apprentice to the firm of Taylor and Challen, of which his father was a partner, and on completion of his apprenticeship he went for about 12 months to the Royal Gunpowder Factory, Waltham Abbey. Returning to the family business, Mr. Challen worked through all the departments, and when the partnership was converted to a limited liability company under its present style in 1889, he was appointed a director. In 1902 he became managing director, and in 1937, on the death of his father, he took over the chairmanship as well.

It was under Bernard Challen's leadership that the company gradually gave up its original business of general engineering, and took to specialising in the manufacture of power presses and allied machinery. New designs for coining presses were developed by Mr. Challen about 1900, and large numbers of these presses were sold in all parts of the world.

Primarily an engineer, and never happier than when he was engaged with a technical problem, Challen was nevertheless fully aware of the need for personal contact with his firm's customers, and he made many journeys to different parts of the world for this purpose. Some of his travels took place well before the first World War, when the idea was by no means generally accepted as a good one; his last overseas journey was to the Scandinavian countries when he was nearly 90 years old.

A graduate of the Institution of Mechanical Engineers in 1889, Challen became a Member in 1897, and served as chairman of the Midland Branch of the Institution in 1929, and again in 1931 and 1932. He was one of the moving spirits behind the establishment of the James Watt Memorial Institute in Birmingham, and became a Trustee and chairman of the Management Committee, holding both offices until 1935, when he resigned on account of advancing years. That was his only concession to age, for he remained physically active and mentally alert right o the end of his long life and was, in fact, at his office only the day before he died.

Bernard Challen was representative of a type of engineering employer which is all too rare to-day. Having gone through all the departments of the business, he knew it intimately. He knew the employees, and they knew him. He was approachable, fair and reasonable in his dealings, but not "soft"; in short, he was the type of man the Birmingham engineering industry understands and gets on with well.

He married, in 1901, Clare Keeling, and had a daughter and two sons; both the latter, Mr. J. B. and Mr. H. D. Challen, are directors of the business.

MR. VICTOR RILEY

Victor Riley, who died recently at the age of 82, was the eldest of five sons of William Riley, founder of the Riley Motor Company, originally Riley Cycle Company.

His father, William, bought a company making bicycles in 1890 which became the Riley Cycle Company in 1896. In 1903 Victor with his brothers started the Riley Engine Company, to make engines and later cars despite the opposition of their father, who did not believe in the future of the automobile at that time. Some years later, however, their father's company ceased making bicycles and with Victor as works manager, it began making detachable wire wheels for cars. By 1912 they had become the greatest manufacturers of these wheels, supplying over 180 car manufacturers including Rolls-Royce, Napier, Daimler, Benz, Renault and Panhard.

After the 1914-18 war a new company, Riley (Coventry) Limited, started making cars and after the retirement of his father in 1923, Victor Riley became chairman and managing director, a post he held until the company was bought by Lord Nuffield in 1938, after which he continued as managing director and a director of the Nuffield Group until he himself retired in 1939.

It was Victor Riley who directed commercial policy; his brother Percy, who died many years ago, was the designer of the engines and chassis; Alan and Stanley occupied themselves with the design and manufacture of the smart looking bodywork which was one of the great features of the make in those great days.

In 1924, Victor Riley married Miss Dorothy Champney, a well-known competition driver, who survives him with a son and daughter.

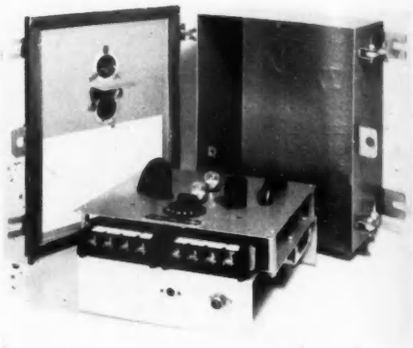
Plant and Equipment

CAPACITY-OPERATED LEVEL CONTROLLER

An advanced development of the Tektor capacity-operated level controller, known as the Tektor Major, has been introduced recently, in which, it is claimed, many of the limitations of the earlier instruments have been overcome. The instrument has been engineered as a stable, reliable level controller, easily installed and requiring virtually no attention after installation. Made by Fielden Electronics Limited, Wythenshawe, Manchester, it has undergone its field trials successfully.

The capacity-operated level controller (ENGINEERING, August 9, page 177, 1957), it may be recalled, comprises a probe and an electronic unit. The probe is normally inserted through the side of the container, and as the material (which may be a liquid, slurry, or solid granular material) approaches or recedes from the probe the electrical capacity changes, operating an electronic circuit. No moving parts are necessary in the liquid container and actual contact between probe and material is unnecessary.

The particular properties of the Tektor Major instrument are as follows. The sensitivity of the Tektor Major is better than 1·0 pF under all conditions. Negligible effects ensue from



The Tektor Major is a level controller for liquids or granular materials using electrical capacitance for its working principle.

(*a*) a ± 10 per cent. change in supply volts, (*b*) an ambient temperature change of from —20 deg. to 50 deg. C., or (*c*) a lapse of time. In the case of the control point, the zero drift as a result of these conditions is: (*a*) not more than ± 1·0 pF, (*b*) not more than 2·0 pF (referred to 20 deg. C.) and, (*c*) not more than ±1·5 pF.

The relay is of the contactor type with a guaranteed switching capacity 440V 5 amp. a.c. non-inductive. For the high-level model, standard lengths of cable are 6, 12, 20, 30 and 35 ft. maximum, and for the low-level model, 6, 12 and 20 ft. This increase in cable length is a great advantage in that the Major unit may now be installed some distance away from the probe. A cable selector switch is fitted enabling the appropriate cable length to be accommodated on site. The performance of the instrument is independent of cable length up to the stated maximum.

A voltage selector switch is fitted, enabling the instrument to be set, on site, for any supply in the 110-125, 220-250 and 380-440V ranges, 40-60 c/s. The performance is again guaranteed at any voltage and frequency in this range.

Other advantages of the Tektor Major include a calibrated set-point control knob inside the case, enabling the set-point to be easily adjusted on site. To facilitate servicing, the chassis can be removed quickly and easily by a simple quarter-turn on the holding screws.

SHAFT-DRIVE GAS-TURBINE FOR AIRCRAFT

A new gas-turbine aero-engine is to be developed by D. Napier and Sons, Limited, The Vale, London, W.3, designed primarily for helicopters but available also as a propeller-turbine for fixed- or rotary-wing aircraft. A smaller version of the Napier Gazelle, which powers the Westland Wessex naval helicopter, it has been named the Gazelle Junior. It is the result of a market survey which indicated an imminent need for an engine of this class for the next generation of single- and multi-engined helicopters. To widen its scope, the Gazelle Junior will also be offered as a coupled engine so that the larger types of single-engined helicopters may be converted to twin-engined types.

An outstanding feature of the standard Gazelle is its large range of installation positions, from horizontal to vertically upright. This feature is also a characteristic of the Gazelle Junior.

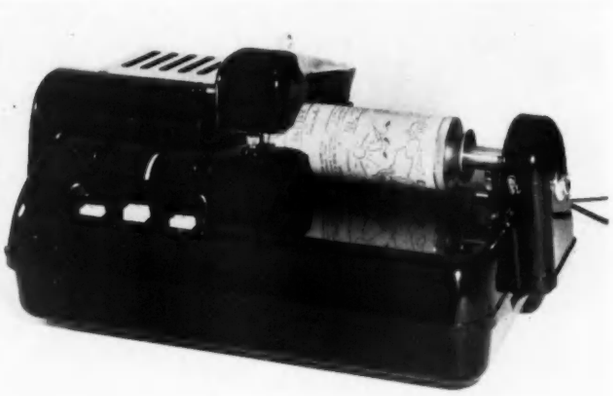
The initial engine will have a sea-level static maximum power rating of 920 s.h.p. which, with development, will be increased to 1,070 s.h.p. Initially, the one-hour rating will be 765 s.h.p., and the maximum continuous rating 680 s.h.p.; in the developed form these ratings will be, respectively, 900 s.h.p. and 800 s.h.p. The maximum diameter of the engine is 33 in. and the length 54 in. The basic weight is 495 lb.

Continuing **Plant and Equipment**

TRANSMITTING FACSIMILES OVER THE TELEPHONE

The Hellfax transceiver enables facsimiles of any document or drawing to be sent or received either through the ordinary telephone system or by radio. The usable area of paper is 190 mm. by 138 mm. (approximately 7½ in. by 5½ in.) and the transmission time to fill this area is approximately 3½ minutes. This corresponds to a speed of about 850 characters per minute, compared to the 400 per minute of the ordinary teleprinter. The transceiver is being marketed in this country by K. S. Paul Limited, Great Western Trading Estate, Park Royal-road, London, N.W.10.

One of the units is shown in the accompanying illustration. The original document is wrapped round a drum which is rotated by a synchronous motor. One switch starts the transmission and another the reception after communication has been made over the telephone. The two units are synchronised by being connected to the mains supply; this limits the use of the system to areas fed from a common grid, but this prevails over most of Britain. The scanning head then reads the document photoelectrically and the impulses are transmitted to the receiving instrument. Reproduction is by electro-mechanical means, a small printing wheel (continuously inked) producing a succession of dots on the paper. These dots have a density of about 1,000 per sq. cm. so that good definition is obtained even under poor transmitting conditions. Reproduction is in one colour only, although the original may be in several. The copy is made on ordinary writing paper. As the units are identical transmission can be in either direction.



Exact reproductions of documents on ordinary paper can be made over telephone lines by the Hellfax transceiver.

The drum revolves at 187·5 r.p.m. and has a feed of 127 lines per inch. The carrier frequency is 2,400 c.p.s. and the maximum dot frequency 1,250 per sec. Normal operating voltage is 220 V at 50 cycles and the consumption is approximately 120 VA. The instruments weigh about 37½ lb. and measure 20·8 in. by 11·8 in. by 10·6 in. high. They have been approved for use on Post Office lines.

PRECISION LENGTH-MEASURING MACHINE

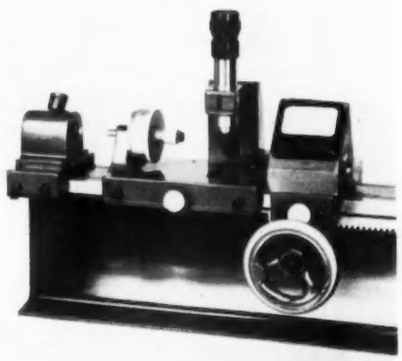
A range of precision length-measuring machines for determining fairly long lengths, developed recently by Hommel Werke, Mannheim, Germany, is being marketed in the United Kingdom by Rubert and Company, Limited, Chapel-street, Stockport-road, Levenshulme, Manchester, 19. Both internal and external measurements can be determined, the measuring operation being based on a comparison of the length of the workpiece either with a combination of slip-gauges approximately equal to that required or with a graduated scale mounted in the bed of the machine—according to the degree of accuracy necessary.

The main parts of the measuring machine, which is shown in the accompanying illustration, are the bed, the fixed saddle on the extreme left and the spindle slide with the sliding saddle on the right. The bed consists of a strong I-section beam. The upper flange has rectangular guides on which the saddles slide. The scale, which is graduated in centimetres or half inches, and which enables the distances between the two saddles to be adjusted as required, is mounted in the centre of the saddle-guides. The graduation of the scale is reproduced photographically from an officially tested master scale, providing, it is claimed, a far higher degree of scale accuracy than is possible with graduating machines operated mechanically.

The fixed saddle, rigidly connected with the bed, carries a spring-loaded measuring anvil used for positioning the workpiece and for setting the machine.

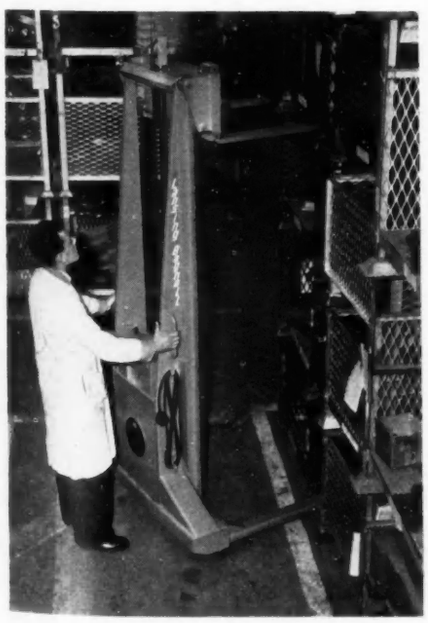
The spindle slide enables the machine to be set to given measuring lengths and readings to be taken of the actual dimension of the workpiece. On the side facing towards the workpiece it is fitted with a powerful micrometer mechanism with a graduation corresponding to differences of 0·002 mm. or 0·0001 in. To provide reflection-free readings, the drum and the shaft element are chromium-plated with a dull finish; the figures and marks are black. The measuring range of the micrometer is 13 mm. or ½ in. Any errors resulting from wear can be compensated. The spindle slide can be very accurately and rapidly set to a given distance from the rigid saddle, by a setting microscope mounted on a supporting arm of the spindle slide. The operation of setting the spindle slide is carried out with the sliding saddle, which is connected to the slide by a precision adjusting screw.

The coarse adjustment of the saddle and slide is carried out either by sliding them along by hand or by a hand-wheel operating a pinion engaging on a rack on the bed. The sliding saddle also carries an indicator instrument connected electrically with the measuring anvil in the fixed saddle; during the advance of the micrometer mechanism (in measuring operations) or of the spindle slide (when adjusting with slip-gauges) the indicator shows when the zero-point has been reached. The position indication transmitted electrically to the instrument in the sliding saddle offers a very important advantage over a mechanical indication in that the operator can see clearly in front of him, and in one spot, all adjusting and indicating elements required for the measuring operation.



Either slip gauges or a graduated scale can be used as a comparator for measuring the length of work-pieces, according to the accuracy required.

Accessories recommended for use with the machine include special equipment for the rapid measurement of U-shaped centre distance gauges, roller bearing saddles for supporting long workpieces and reference gauges, and adjustable mounting feet for setting up the machine on a floor. Special sets of slip-gauges are available, and universal holders for building up combinations of slip-gauges; pincers and temperature-insulating gloves are supplied for handling gauges and workpieces, and precision thermometers are available for controlling the temperature in the measuring room.



STACKING TRUCK FOR CONFINED SPACES

A hand-propelled fork-lift truck for use in extremely confined spaces has been put on the market by Lansing Bagnall Limited, Kingsclere-road, Basingstoke, Hants. One model is shown in the illustration. The lifting mechanism is of the electro-hydraulic type, power being supplied by a 12 volt battery. Lift heights up to 84 in. can be provided with a lifting speed of 10 ft. per minute. The truck is capable of handling loads of 1,120 lb. at 15 in. centres in gangways less than 6 ft. wide. Incorporated in the body is a battery charger, and re-charging is effected simply by plugging-in to a mains supply. Straddle widths of up to 42 in. are available and the forks themselves can be adjusted across the whole face of the carriage.

Special Article

FLOODLIGHTS FOR THE FALLING WATERS OF NIAGARA

By T. G. Proctor and H. F. Stephenson

About two years of research, design and development lie behind the brief announcement that the contract for lighting Niagara Falls has been awarded to the Amalgamated Electric Corporation, an associate of the General Electric Company Limited of England.

In 1955, the Niagara Falls Illumination Board decided that the existing lighting required improving, and invited specialist lighting firms to submit proposals. Details of the project reached England in July of that year, the terms of reference being that no increase in the power supply could be provided, that the new system must give more light and that any proposals to improve the lighting of the falls would be considered.

It was at this stage that a team of lighting engineers from the General Electric Company's Head Office and its Research Laboratories at Wembley began their initial appraisal of the project. Both Mr. T. G. Proctor and Mr. H. F. Stephenson are with the General Electric Company Limited of England.

The general topography of the Niagara Falls area is shown in Fig. 1 and the new scheme can be best appreciated if the existing lighting installation is described first. Twenty-four 36 in. diameter floodlights containing low-intensity carbon arc lamps, running at 125 amperes, are used for the existing lighting. The carbons are about 1 in. in diameter with an electromagnetic ratchet mechanism controlled by the arc voltage to feed them forward. The floodlight barrel contains a paraboloidal silvered glass reflector with a focal length of 34 cm., providing a beam of about 3½ deg. minimum divergence. The quoted peak intensity is 55 megacandelas.

Power is supplied from a 375 kW, 250 V direct-current motor-generating set in the Ontario Power Station, a hydro-electric station situated in the lower gorge downstream from the Horseshoe Falls. Two rotary balancer sets are used, each of 55 kW capacity, to give a three-wire system with 125 V between each outer and the centre wire. A three-core 1,500 ampere cable is provided between the power station and the floodlights mounted on the parapet of the surge-tank building belonging to the Hydro Station in the Queen Victoria Park (Fig. 3).

Twelve arc lamps are connected between each outer and the centre wire, via individual series ballast resistances. The total load for each lamp is 15·6 kW so that the permissible out-of-balance load corresponds to about three floodlights being extinguished at any one time in each group of twelve.

Half the floodlights are used to light the American Falls and the remaining half to light the Canadian (Horseshoe) Falls. The floodlights are trained so that the circular light patches marry together side by side to cover the width of the Falls. Most units are defocused slightly to obtain sufficient beam spread to cover the vertical

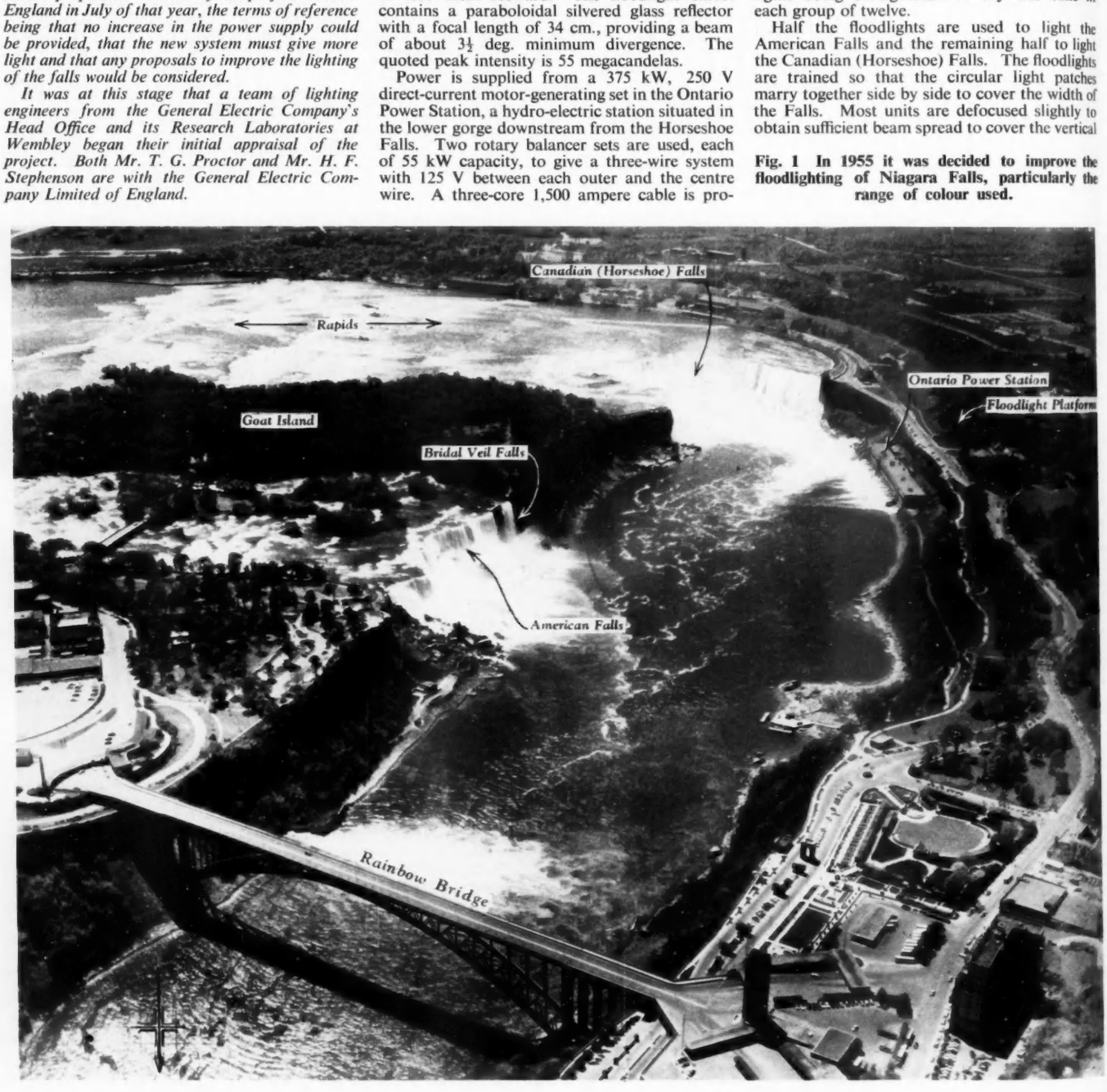


Fig. 1 In 1955 it was decided to improve the floodlighting of Niagara Falls, particularly the range of colour used.

height. Colour screens can be placed manually on the front of each floodlight.

Floodlighting of the Falls takes place every evening and lasts for about 2½ hours. A typical programme comprises steady white illumination for the first half-hour followed by coloured lighting for one and a half hours, weather permitting, and concluding with half an hour of white light. With the wind in certain directions the great plume of spray in the centre of the Horseshoe Falls is blown directly on to the searchlight rotunda, making conditions there distinctly unpleasant for the operators changing coloured screens. In winter, this spray freezes and the rotunda becomes a slippery and dangerous place on which to work. Finally, spray on the colour screens themselves is boiled off the surface by the heat from the lamp, causing wrinkling and rapid deterioration of the material, and it is for these reasons that colour is not always included in the programme.

Although the Falls had been lit by electricity for short periods on many occasions, the first in 1879, the equipment described above was the first permanent installation. It was provided from money raised by a joint committee representing the cities of Niagara Falls on both sides of the border and the Queen Victoria Park Commission, power being supplied free by the Hydro-Electric Commission of Ontario. The installation was inaugurated on June 8, 1925, during the Power and Progress Exposition commemorating the 30th anniversary of hydro-electric power production on a large commercial scale at Niagara.

After nearly thirty years of service the installation has deteriorated in spite of careful maintenance. Recent measurements indicate that the floodlights now give considerably less than their original intensity and the lighting effect on the Falls, although reasonable with white light, provides only a mediocre colour display.

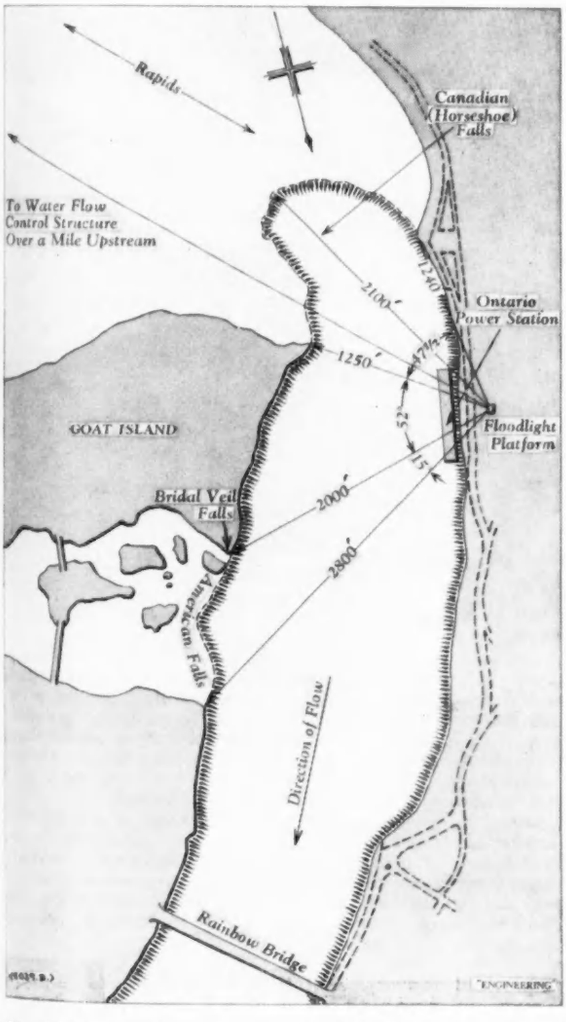


Fig. 2 The lengths of throw, and the horizontal beam widths needed to cover the falls fully, were marked out on a scale plan.

APPRAISAL OF PROJECT

Apart from the requirements stated earlier, it was stressed that because of the winter weather conditions an alternative to the present manual method of colour changing was desirable, and also that expensive new heavy current cabling should be avoided if possible. The problems may therefore be summarised as: the provision of as much light as possible for the same power; some form of remote-controlled or automatic colour changing giving ten colours, with suitable weather protection for the colour media; examination of alternative sites for the floodlights to see whether these, together with any method of lighting other than the long-throw projection used hitherto, might prove more spectacular.

Study of the topography showed that with the power station on the Canadian side of the river, it would be expensive and difficult to provide cabling for close offset lighting, particularly on the American and Bridal Veil Falls. The few likely sites were exposed to spray and almost certain ice damage. For similar reasons, one idea of lighting part of the Horseshoe Falls through the vertical sheet of water from the observation tunnel which runs behind them was abandoned. Reverting to long range lighting, the two possible sites were either on the roof of the power station or at the existing position. Of these, the former was the more exposed to spray. Also, the sight lines of many visitors viewing the Horseshoe Falls would be nearly coincident with beam directions passing through the largest amount of spray and, due to back scatter of the light, this would give the worst seeing conditions. Finally, the power station roof was 86 ft. below the crest of the Horseshoe Falls, making it impossible to light the upper rapids. The final choice, therefore, was the existing site using long-range lighting, any variation in lighting effect to be obtained with several different beam shapes and with a suitable arrangement of lighting patterns.

A survey of likely sources was made to find a high-brightness lamp with a spectral energy distribution suitable for the effective use of colour filters. It was thought desirable to have a replaceable lamp requiring no maintenance so that the re-carboning and servicing needed with any carbon arc lamp could be avoided in the exposed weather conditions.

Various lamp types were discarded either because of their low source luminance (lower than the existing low-intensity arcs), as with the high wattage filament lamp, or because of their poor colour, as with the high brightness compact-source mercury vapour lamp and its variations. The difficult conditions of damp and ice found on the floodlight platform also caused some problems in the use of high-pressure lamps.

Finally, in spite of the maintenance required, the well established high-intensity carbon arc lamp was chosen. In such a lamp the light source is substantially a ball of luminous vapour from the cerium fluoride core of the positive carbon. The luminance is more than three times that of a low-intensity arc and this increase in luminance is very desirable for long-range narrow-angle projection. It permits high beam intensity with a relatively small diameter optic, an important consideration in view of the restricted space available for the floodlights. The colour is blue-white, and the spectral energy distribution enables rich colours to be obtained with appropriate colour filters. Because of the high effective colour temperature, there is an adequate proportion of blue light, which is lacking in the present installation.

To utilise all the available power and to provide sufficient projectors to give a varied colour pattern on the Falls, a lamp rating of 75V, 150 amperes was chosen, which allowed 20 projectors to be used. In this rating several well tried lamp mechanisms had been developed. Because of the high burning rate of the positive carbon (some 9¼ in. per hour) a carbon long enough to last for one complete evening's performance could not be accommodated in a barrel of acceptable length. The first proposal was to fit a magazine-type lamp which changes its own carbons and can burn for as long as

Fig. 3 A survey of possible locations for the lights showed that the present site on the top of the power station surge tank building still offered the best spot.

6 hours if required but, because of the high cost of the mechanism, a semi-automatic lamp was adopted which would require the positive carbon to be changed once per night, that is, half way through the performance. The "feed-up" of both carbons at a rate equal to their burning rates is effected by a geared motor drive, the speed of which is determined by the arc voltage. From the various designs of lamp, that developed by Savage and Parsons Limited, was adopted. Features of this lamp were the narrow hollow lamp column giving a minimum of obstruction, efficient cooling of positive brushes, ease of positive carbon replacement and maintenance and neat design of the positive head.

OPTICAL SYSTEM

From photographs of the Falls and a large scale plan, an angular web was calculated and superimposed on a photograph of each Fall specially taken from the floodlight position. Fig. 4 shows the composite picture for the Horseshoe Falls, the angles signifying the angular subtense of any part of the Falls at the floodlights. From these webs the beam angles needed to cover any area could be determined and Table I and Fig. 2 summarise the essential geometry of the installation.

Since the angular width of the Horseshoe Falls is about three times that of the American Falls, it was proposed to divide the 20 units into two groups, one group of 15 to light the Horseshoe Falls and one group of 5 to light the American Falls. With such an arrangement a horizontal beam width of about 3½ deg. would allow full coverage. Vertically, a greater divergence is needed, particularly for the Horseshoe Falls, some of which would be provided by the tail flame of the arc. At this stage there was no reliable information as to the effect of spray in spreading the beams and, in fact, this remained an unknown quantity until some 18 months later when a prototype unit was taken to the Falls for a demonstration.

In view of the uncertainty it was decided not to design at this stage a special asymmetric

Continuing Floodlights

reflector which would give a beam shape exactly matched to the Falls. The alternative was a reflector giving a symmetric beam which could be modified by suitable spreader glasses. An optical system giving a minimum beam divergence of 1·8 deg. was chosen: this used a 90 cm. mirror (the maximum diameter which space permitted) of 42 cm. focal length. With this arrangement the beam could be defocused to about 4 deg. The reason for this choice of optical arrangement rather than one giving the required divergence of 3½ deg. when in focus was that if it should be found that spray was spreading the beam, the effect could be counteracted by bringing the lamp more nearly into focus.

The first specification for the equipment included the straightforward optical design described above. Later, in tests with a prototype unit during a demonstration in England, when the Falls were simulated by using water from fire hoses, and smoke bombs were used to represent the effect of spray, two special front glasses were selected. One was a fluted glass which, when placed in front of the fully focused floodlight, spread the beam in one direction to about 13 deg. without appreciably altering the divergence in the other direction. The second glass gave about double the divergence in all planes together with a soft-edged beam. The floodlight thus became a unit capable of providing a number of different beams all of which were used in the final lighting plan.

Much exploratory and development work went into finding suitable colour media, a means of introducing them into the beam by remote control, and for keeping them under the right conditions to avoid cracking and fading. Following many experimental mock-ups a colour-changing device containing a group of five colour filters was evolved. The colour media were of "Cinemoid," a dyed cellulose acetate film. Each filter was about 37 in. square, being carried by a counter-weighted metal frame driven by an individual motor. The whole was contained in a weather-proof housing, measuring 8 ft. high by 4 ft. wide by 2 ft. deep, to be fixed to the front of the floodlight. The filters could be used either singly, or in combinations of two or three, to give 15 useful colours from the many possible combinations, thus more than satisfying the required 10 colours. Considerable thought was given to the problem of keeping the filter media cool and to minimise fading of the colours. It is expected that a useful life of 9 to 12 months will be obtained.

THE COMPLETE UNIT

A prototype floodlight, with the colour changer mounted in position, is shown in Fig. 5. Many difficulties introduced by limited space on the rotunda have been overcome, and the overall length is only 6 ft., the width 4 ft. and the height about 9 ft. Elevation or depression of the unit is adjusted within the limits of + 9 deg. and − 12 deg. by a screwed knuckle-joint at the rear of the floodlight, and training is controlled from the centre spigot on the trunnion. Normally, the unit will be used with the beam directed at a predetermined point on the Falls, and with one or other of the special glasses mounted inside the clear front glazing of the colour changer.

For public holidays such as the American Independence Day, it is customary to provide a searchlight display, and the beams have to be directed vertically upwards. Mechanical difficulties make it impossible to elevate the complete unit and it is necessary to remove the colour changer by means of a jacking trolley. Movable balance weights are provided so that the floodlight barrel itself can be re-balanced about the trunnion supports for these occasions.

The floodlight barrel contains the arc lamp and mirror, with the carbon "feed-up" mechanism housed in a separate box recessed into the side. To permit the positive carbons to be inserted in the restricted barrel length, the lamp is racked 5 in. towards the mirror, and limit stops ensure correct re-positioning after re-carboning. Wide-angle flexible joints are provided on the drive rods between the "feed-up" mechanism and the lamp to allow it to be moved in this way. A "Focuscope" (which shows visually whether the carbons are correctly positioned), carbon-replacement warning light, extractor fan, access doors for servicing and the re-carboning light inside the barrel follow conventional searchlight practice. An isolating switch is provided on the barrel.

The colour changer unit incorporates special weather-proofing and quick-release toggle catches to allow easy access to the inside. The front and back glazing is of toughened glass, to withstand not only heat combined with cold spray but also the stone throwing activities of small boys. Each colour screen moves in guides with large clearances to avoid icing troubles. The total travel of the screens is limited by micro-gap switches placed at each end of the guide channels. Power supplies and wiring from the remote switchboard are connected to the colour-changer by a waterproofed 12-way multi-plug and socket.

The remote control switchboard takes the form of a console, so that it can be operated from a sitting position while viewing the effect on the Falls. A panel inclined at 45 deg. carries 20 vertical banks of switches with an indicator showing the colour controlled by each row. Each bank of switches comprises five two-way and off toggles, so that all five switches for each individual colour controller are sited one below the other. The over-riding master switch operating through 20 relays enables each colour sequence to be preset and brought into effect by the operation of the master controller.

In addition to rust and corrosion, the problems of condensation, extremes of temperature and icing-up of access doors, hinges and catches had to be considered. Throughout the design and construction care has been taken to guard against the effects of these unusual weather conditions and to ensure long life and reliability of the equipment.

INSTALLATION LAYOUT

Although the basic design of the lighting equipment had been completed in Britain by July, 1956, and a specification sent to Canada.

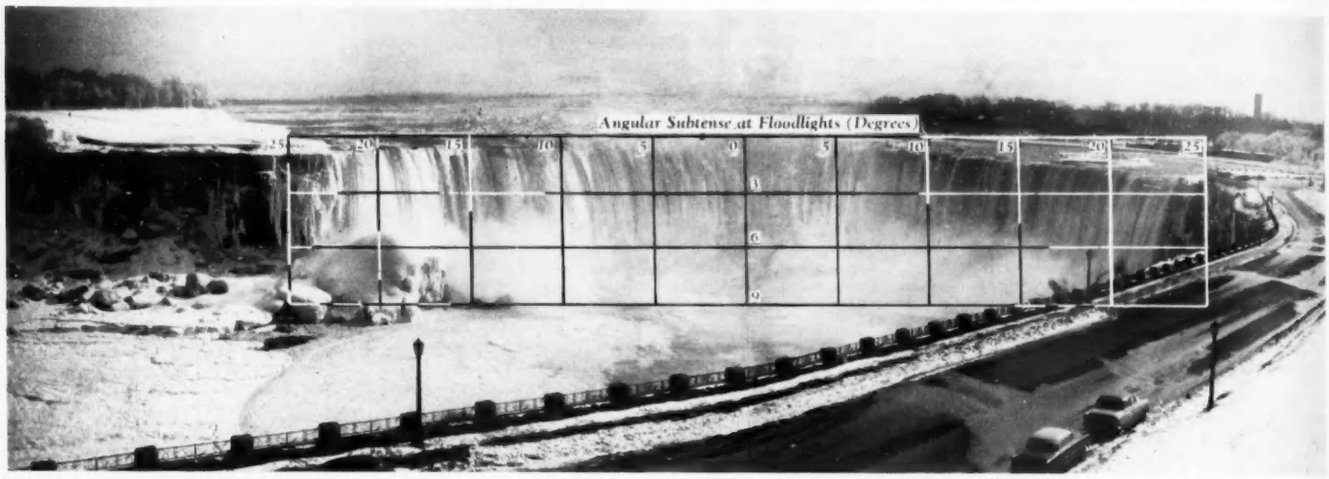


Fig. 4 (above) Subtense angles were determined from a grid marked on composite photographs to ensure full coverage.

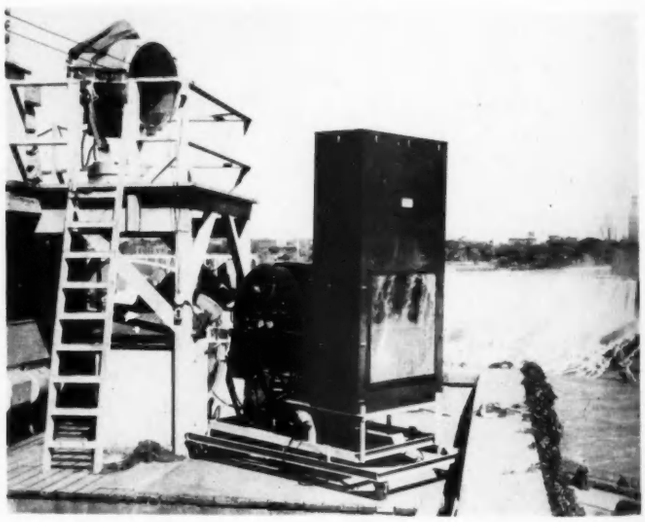


Fig. 5 (right) The prototype of the new lights shows the totally enclosed colour-changing arrangements, which have remote control operation.

TABLE I *The Geometry of the Niagara Falls Installation*

Orientation	Angular subtense at floodlights (degrees)	
	Horseshoe Falls	American and Bridal Veil Falls
Horizontal	47½ total	15 total width
	16½ L.H.S. of spray plume	12½ American Falls only
	14½ R.H.S. of spray plume	¾ Bridal Veil Falls only
	16½ actual plume of spray	
Vertical		
Crest to river level ..	8½	4¾ at north end
		6¼ at south end
Actual vertical sheet of water	5 to 6	3 to 4
Spray plume	24 (varies with water flow and wind strength)	—
Upper Rapids ..	2¾	—
Crest of Horseshoe Fall to river level at flow control structure over a mile up river.		

TABLE II *The Final Arrangement of Floodlights*

Part of Falls	Number of floodlights	Type of beam proposed
American	4	Fully focused horizontal fans arranged one above the other.
Bridal Veil ..	1	Fully focused soft edged beam.
Horseshoe: *L.H.S. and R.H.S.*	4 each	Fully focused horizontal fans arranged one above the other.
Spray plume ..	2	Fully focused vertical fans, side by side.
Rapids	3	One horizontal fan above crest. Two fully focused hard edge narrow beams side by side lighting up river.
Goat Island ..	2	De-focused horizontal fans side by side to cover full height of rock edge and link the two Falls.

TABLE III *Characteristics of the Original and the Latest Arc Lamps Used for Lighting Niagara Falls*

Date	1879	1957
Arc volts	45	75
Arc current	10	150
Arc watts	450	11,250
Arc crater intensity (candelas) ..	1,380	106,000
Arc crater luminance (Cd per sq.cm.)	16,000	80,000
Light output (lumens)	7,600	360,000

it was not until one prototype unit was taken to the Falls for a demonstration in September, 1957, that it became possible to resolve points not answered by looking at plans and photographs, and to assess the best way to utilise the various beam patterns in lighting the Falls.

To a visitor viewing the Falls in daytime the panorama is impressive, principally because the eye moves horizontally across the 1,000 ft. width of the American Falls, and continues across the rocky face of Goat Island to the broad 2,600 ft. sweep of the Horseshoe Falls with the great plume of spray at its centre. Above the Horseshoe Falls the rapids extend over a mile up-river, while the vertical height of the waterfalls is put into proper perspective by comparison with familiar objects such as buildings, trees on Goat Island, and people close to the Falls.

At present, only the two vertical sheets of water are lit, with Goat Island, the rapids, and the plume of spray hidden in the darkness. The effect of the panorama is lost and the view becomes that of two disconnected waterfalls; also, since familiar objects are not visible the true magnitude of the Falls cannot be assessed.

Although both white and coloured light can produce many interesting effects, it seemed to us that much more was required of the lighting. The present installation produces circular light patches side by side which tend to break up the width. If most of the panorama could be revealed and if lighting in broad horizontal bands were used a more satisfactory visual effect could be produced.

Tests with the various beam shapes were made with this concept in mind and the floodlight with the spreader glass was found to cover the full width of the American Falls and about a quarter of its height. Similarly, the same beam covered the sections of the Horseshoe Falls to the right and left of the spray plume. Incidentally, beams passing through thin layers of spray produced attractive rainbow effects. By rotating the spreader glass through 90 deg., the spray plume could be lighted effectively with a vertical band of light. The most concentrated beam was needed to light the rapids well up-river, but the horizontal wide fan revealed dramatically the foam for some hundreds of yards above the crest. On the Bridal Veil Fall a more pleasing effect was obtained with the circular soft edged arrangement than with a de-focused primary beam. Finally, two wide-fan beams well de-focused could light the rock face of Goat Island adequately to link the two Falls together.

Fortunately, the new unit has sufficient intensity even with the extra beam spreads introduced by the glasses to permit an effective coloured display over the much larger area envisaged in the new proposals with only the 20 units available. The final scheme, which was demonstrated before the Niagara Falls Illumination Board in sequence using the one prototype projector, is shown in Table II which indicates the allocation of floodlights.

It will be appreciated that the flexibility of the unit with its many beam patterns and remote-control colour changing allows the designer to alter the lighting pattern to produce new concepts of light, shade and colour as often as is required to provide new spectacles to attract visitors.

Luminance measurements on the lighted area of the Falls given by one of the existing floodlights and by the prototype unit were taken. For the same beam-spread, the existing unit gave a luminance of 0·3 ft.-lamberts (ft.-L.) compared with 5·5 ft.-L. for the new unit. When fully focused the new unit gave 14 ft.-L. and with the wide-fan beam 1·5 ft.-L.

From these figures and from the known intensity of the focused beam it may be deduced that the effective reflection factor of the vertical water sheet is about 35 per cent.

In conclusion, Table III contrasts the performance of the new high intensity arc with that of the " Brush 2,000 candle-power open arc " lamps used for the first illumination of the Falls in 1879.

RESEARCH CO-OPERATION IN THE COMMONWEALTH

A useful compendium of information called " The Promotion of the Sciences in the Commonwealth " has been issued by the reference division of the Central Office of Information. This provides a list of the learned societies, research organisations and standards organisations within the Commonwealth. As would be expected, there has been much more development in agriculture, forestry and mining than in most other kinds of research work. Thanks, however, to the important part which Canada has played in the development of atomic energy the collaboration on this subject seems to be significantly greater than in most other types of advanced industrial technology.

An interesting section deals with the degree of co-operation. Again agriculture, as might be expected, has had a big start but there has been a useful series of conferences on standards over the years, which culminated in a Commonwealth Standards Conference at this time in 1957 in India where technical sessions discussed standards for electrical equipment, machine tools, electric cables, and steel, and safety requirements for domestic electrical appliances. Conferences on engineering standards have been held since 1945 between the United Kingdom, Canada and the United States, known as the ABC Conferences.

Since 1948 a British Commonwealth Scientific Office has existed in London which operates in conjunction with the scientific offices in London of Commonwealth countries, and in close collaboration with the Overseas Liaison Division of the United Kingdom Department for Scientific and Industrial Research. One of the jobs these offices have begun is a Commonwealth index of translations into English of published scientific papers, reports and journal articles.

The most important form of co-operation in nuclear energy has been the interchange of students and staff between universities and nuclear energy establishments. Collaboration among the African members of the Commonwealth is achieved by C.C.T.A. (Commission for Technical Co-operation in Africa South of the Sahara—known by its French initials) which is not a Commonwealth organisation but a commission including French and Belgian representatives as well as the United Kingdom. It is apparent that a framework of co-operation is gradually being evolved within the Commonwealth so far as the exchange and cataloguing of research work is concerned and that this is likely to overlap with regional organisations doing the same kind of thing. For example, what has happened in Africa may be expected to develop in South-East Asia. It is in everyone's interests that there should be a full exchange of scientific data but it will also be helpful if the work can be co-ordinated at a high level by some international organisation so that the records are neither duplicated nor piecemeal.

INCREASING REFINERY CAPACITY IN EUROPE

One of the features of post-war industrial development in Europe has been the rapid expansion of oil refinery capacity. For non-Communist Europe capacity now is about 134 million tons, compared with only 22 million tons ten years ago. Major projects in hand or under consideration will add almost another 100 million tons. The locating of new capacity in the consuming, importing countries is a distinctive feature of post-war development. Another is the changing pattern of market demand due to the greatly increased use of fuel oil. This has reduced capital costs as full-scale cracking facilities are not required.

The completion of the projects now in hand in Europe will bring an increase in capacity of 30 million tons in Western Germany, 21 million tons in Britain, and 9 million tons in Benelux. Plans announced for France cover 10 million tons new capacity. Italy already has a large surplus capacity and it seems unlikely that any further refineries will be built, except in Sicily. Switzerland, which is at present the only European country other than Luxembourg and Iceland without a refinery, is to have a small plant erected at Stabio by an Italo-Swiss group.

Many of the new refineries will be situated well inland. Three of these are sited at Strasbourg, Karlsruhe, Châlons-sur-Saône. Owing to the congestion on the Rhine a pipeline is being built from Wilhelmshaven to the Rhine-Ruhr area. This line will supply the new Esso refinery at Cologne which has a projected capacity of 7·5 million tons, and the B.P. plant at Dinslaken. Other pipelines of varying lengths from Rotterdam, L'Avéra in the South of France, Venice and Genoa are under consideration. This big expansion in refinery capacity is of course only one side of the story. The other is the large capital expenditure in oil exploration and production, ocean tankers and marketing facilities. Even so, refinery expansion in Europe will involve a capital expenditure of not less than £650 million.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Prevention of Accidents: The Responsibility of the Supervising Engineer," by P. W. Cole. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Tues., Feb. 25, 6.30 p.m.*

British Institution of Radio Engineers

LONDON
"Dectra: A Long-Range Navigational Aid," by C. Powell. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Feb. 26, 6.30 p.m.*
CHELTENHAM
"Some Advanced Applications of Information Theory," by P. H. Blundell. South Midlands Section. North Gloucestershire Technical College, Cheltenham. Fri., Feb. 28, 7 p.m.
TREFOREST
"Industrial Television," by R. Swinden and J. E. H. Brace. South Wales Section. Glamorgan Technical College, Treforest. Wed., Feb. 26, 6.30 p.m.

British Interplanetary Society

LONDON
"Guidance and Control of Long-Range Vehicles," by Professor G. A. Witfield. Caxton Hall, off Victoria-street, S.W.1. Sat., Mar. 1, 6 p.m.

Building Centre

LONDON
Films: "The Titanium Pigment Story," exhibited by British Titan Products Co., Ltd. Wed., Feb. 26, 12.45 p.m.

Chemical Society

BELFAST
"Gas Chromatography," by Dr. B. W. Bradford. Northern Ireland Branch. Queen's University, Belfast. Thurs., Feb. 27, 7.15 p.m.
HULL
"Physics and Chemistry of Lubrication," by Dr. C. B. Davies. Hull Branch. Chemistry Department, The University, Hull. Thurs., Feb. 27, 6 p.m.

Combustion Engineering Association

CARDIFF
"Recent Advances in Space Heating," by G. H. Buckle, at 10 a.m.; and "Refractories for the Industrial Boiler and Furnace," by N. W. Hinchcliffe, at 2.30 p.m. Welsh Region. Park Hotel and Whitehall Rooms, Cardiff. Wed., Feb. 26.

Illuminating Engineering Society

BIRMINGHAM
Annual General Meeting. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Feb. 28, 6 p.m.
HULL
"Photo-Electric Cells and Their Applications," by F. A. Benson. Leeds Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Tues., Feb. 25, 6.30 p.m.*
LEEDS
"Photo-Electric Cells and Their Applications," by F. A. Benson. Leeds Centre. Lighting Service Bureau, 24 Aire-street, Leeds 1. Mon., Feb. 24, 6.15 p.m.*

Incorporated Plant Engineers

LONDON
Annual General Meeting. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Feb. 25, 7 p.m.*
BIRMINGHAM
"Maintenance of Transport," by R. Scarth. Birmingham Branch. Imperial Hotel, Temple-street, Birmingham. Fri., Feb. 28, 7.30 p.m.
CARDIFF
"Instrumentation," by J. M. Keating. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Feb. 25, 7.15 p.m.
LEEDS
Discussion on "A Liberal Education in a Scientific World." West and East Yorkshire Branch. The University, Leeds. Mon., Feb. 24, 7.30 p.m.
SHEFFIELD
"Atmospheric Pollution in Industry," by W. Herring. Sheffield Branch. Grand Hotel, Sheffield. Thurs., Feb. 27, 7.30 p.m.

Institute of Fuel

LONDON
"Boiler Water Treatment: A Formula for the Control of Sludge and Scale in Internal (Carbonate) Treatment," by Dr. J. A. Gray; and "Boiler Water Treatment: A Formula for the Control of Sludge and Scale in Internal Carbonate Treatment—Experiments in a Laboratory Boiler," by E. F. Thurston and L. Furnival. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Feb. 26, 5.30 p.m.*
BIRMINGHAM
"Use of Additives to Reduce Boiler Fouling," by W. D. Jarvis. Midland Section. James Watt Memorial Institute, Birmingham. Thurs., Feb. 27, 6.30 p.m.
GLASGOW
"Gas Coke as a Smokeless Fuel in Scotland," by S. Smith. Scottish Section. Royal College of Science and Technology, Glasgow. Thurs., Feb. 27, 7 p.m.

Institute of Marine Engineers

LONDON
"Corrosion Control in Tankers," by A. Logan. Tues., Feb. 25, 5.30 p.m.*
CARDIFF
"The Free Piston Engine and Its Marine Application," by P. A. Watson. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Feb. 27, 7.15 p.m.
LIVERPOOL
"The Junior Engineer's First Trip to Sea," by H. C. Gibson. Merseyside and North Western Section. Riversdale Technical College, Liverpool. Wed., Feb. 26, 5.30 p.m.

Institution of Chemical Engineers

BIRKENHEAD
"Ion Exchange as a Unit Operation," by R. Kressman. North Western Branch. Birkenhead Technical College, Birkenhead. Tues., Feb. 25, 7 p.m.

Institution of Civil Engineers

LONDON
"Prestressed-Concrete Cylindrical Tanks," by L. R. Creasy. Tues., Feb. 25, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Stereophonic Recording on Gramophone Discs," by H. A. M. Clark. Radio and Telecommunication Section. Mon., Feb. 24, 5.30 p.m.*
"Design and Application of Large Solid-Rotor Asynchronous Generators," by P. Richardson. Supply Section. Wed., Feb. 26, 5.30 p.m.*
HULL
"British Columbia-Vancouver Island 138 kV Submarine Power Cable," by Dr. T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson. North Midland Centre. Offices of the Yorkshire Electricity Board, Ferensway, Hull. Thurs., Feb. 27, 6.30 p.m.
PORTSMOUTH
"Route Selection and Cable Laying for the Transatlantic Cable System," by R. J. Halsey. Southern Centre. Offices of the Central Electricity Generating Board, Portsmouth. Wed., Feb. 26, 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Work of the Mechanisms, Engineering Metrology and Noise Control Division of the Mechanical Engineering Research Laboratory," by Dr. C. Timms. Tues., Feb. 25, 6.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
"Growth, Trend and Limitations of Building Warming by Electricity," by J. S. A. Primrose and J. Jamieson. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., Feb. 25, 7 p.m.
MANCHESTER
"Experience in the Firing of Shell Boilers, with Mechanical Stokers and Oil," by R. F. W. Guy. Manchester Branch. Engineers' Club, Albert-square, Manchester. Fri., Feb. 28, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
Sir Seymour Biscoe Tritton Lecture on "Development of Electric Traction in Sweden and Its Influence on Rolling Stock," by E. Upmark. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Feb. 26, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion: "Are We Satisfied with the Quality of Fuel at Present Available for High-Speed Diesel Engines?" Internal Combustion Engine Group. Thurs., Feb. 27, 6 p.m.*
"Design and Construction of the Main Compressor for the 8 ft. by 8 ft. High-Speed Wind Tunnel at the R.A.E., Bedford," by L. J. Cheshire and others. Fri., Feb. 28, 6 p.m.*
BIRMINGHAM
"Some Experiments with Internal-Combustion Engines," by R. C. Cross. Birmingham A.D. Centre. James Watt Memorial Hall, Great Charles-street, Birmingham. Tues., Feb. 25, 6.30 p.m.
BRISTOL
"Prevention of Corrosion in Car Bodies," by T. P. Hoar. Western A.D. Centre. Royal Hotel, Bristol. Thurs., Feb. 27, 6.45 p.m.
DUNDEE
Thomas Lowe Gray Lecture: "Machinery in Cross-Channel Passenger Ships," by E. L. Denny. Scottish Branch. Technical College, Dundee. Fri., Feb. 28, 7.30 p.m.
SLOUGH
"Some Experiments with Internal-Combustion Engines," by R. C. Cross. Eastern and Southern Branches. Good Companions Hotel, Slough. Thurs., Feb. 27, 7.30 p.m.

Institution of Production Engineers

CARDIFF
"Use of Time-Lapse Photography in Work Study," by A. G. Northcott. Cardiff Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., Feb. 28, 7 p.m.
DERBY
"Nuclear Power and the Production Engineer," by I. Munro. Derby Section. College of Art, Derby. Fri., Feb. 28, 7 p.m.
HALIFAX
"Wire Production," by C. Coates. Halifax and Huddersfield Section. White Swan Hotel, Halifax. Thurs., Feb. 27, 7.30 p.m.
STOKE-ON-TRENT
"Design for Production," by F. E. Butcher. Stoke-on-Trent Section. Grand Hotel, Hanley, Stoke-on-Trent. Mon., Feb. 24, 7.30 p.m.

Institution of the Rubber Industry

MANCHESTER
"Design and Testing of Rubber Engineering Components," by A. R. Payne. Manchester Section. Grand Hotel, Manchester. Mon., Feb. 24, 6.45 p.m.

Institution of Structural Engineers

LONDON
"Problem of Mechanical Handling in Building Operations," by J. F. Eden and D. Bishop. Thurs., Feb. 27, 6 p.m.*
BIRMINGHAM
"Some Notes on the Use of High Preload Bolts in the United Kingdom," by F. M. Easton, E. M. Lewis and Dr. D. T. Wright. Midland Counties Branch. James Watt Memorial Institute, Birmingham. Fri., Feb. 28, 6 p.m.
SCUNTHORPE
"Advantages and Disadvantages of Structural Steelwork, Reinforced Concrete and Prestressed Concrete," by Donovan H. Lee. Yorkshire Branch. Blue Bell Hotel, Scunthorpe. Wed., Feb. 26, 6.30 p.m.

Junior Institution of Engineers

LONDON
"A Fully Educated Engineer," by Dr. W. Abbott. Fri., Feb. 28, 7 p.m.*

Manchester Association of Engineers

MANCHESTER
"Brushless Variable Speed Induction Motors," by Professor F. C. Williams. The University, Manchester. Fri., Feb. 28 6.45 p.m.

Manchester Metallurgical Society

MANCHESTER
"Metallurgy of Tantalum, Niobium and Beryllium," by Dr. G. L. Miller. Central Library, Manchester. Wed., Feb. 26, 6.30 p.m.

Modular Society

LONDON
"Development of Standardised Components for a Local Authority Building Programme," by W. D. Lacey. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Mon., Feb. 24, 7.30 p.m.

Royal Aeronautical Society

LONDON
"Guided Flight Trials," by R. W. Boswell. Royal Aero Club, Londonderry House, 19 Park-lane, W.1. Tues., Feb. 25, 6 p.m.
Presidential Address by Sir George Edwards. Church House, Great Smith-street, Westminster, S.W.1. Wed., Feb. 26, 6 p.m. (Followed by a reception at 4 Hamilton-place, W.1. Tickets 21*s.*)

Royal Institution

LONDON
"Energy," by Professor R. King. Juvenile lectures I and II. Tues. and Wed., Feb. 25 and 26, 5.30 p.m.

Royal Society of Arts

LONDON
"Second Indian Five-Year Plan," by Geoffrey Tyson. Thurs., Feb. 27, 5.15 p.m.*

Royal Statistical Society

LEICESTER
"Machine Interference," by F. Benson. Leicester Industrial Applications Group. College of Technology, The Newarke, Leicester. Thurs., Feb. 27, 7 p.m.

Scientific Film Association

LONDON
"16 mm. Laboratory Techniques," by R. F. Ebbetts. Royal Photographic Society, 16 Princes-gate, S.W.7. Fri., Feb. 28, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Metallurgical Requirements of the Aircraft Industry in Present Conditions," by G. Meikle. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Feb. 25, 7 p.m.

Society of Chemical Industry

NEWCASTLE-UPON-TYNE
"Stress Corrosion Cracking of Stainless Steels," by T. P. Hoar and J. G. Hines, at 2.30 p.m. "Stress Corrosion Cracking of Carbon and Low-Alloy Steels," by Dr. R. N. Parkins, at 5.30 p.m.* Corrosion Group. Stephenson Building, King's College, Newcastle-upon-Tyne. Wed., Feb. 26.

Society of Instrument Technology

LONDON
"Dynamic Characteristics of Pneumatic Transmission," by J. E. Samson. Manson House, Portland-place, W.1. Tues., Feb. 25, 7 p.m.*

Women's Engineering Society

LONDON
"Three Case Studies in Automation," by Geoffrey Denton. London Branch. Electricity Council's offices, Winsley-street, W.1. Wed., Feb. 26, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (BAYswater 9101.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Manchester Association of Engineers, 18 Booth-street, Manchester 2. (Central 1717.)
Manchester Metallurgical Society, The Kennedy Press, Ltd., 31 King-street West, Manchester 3.
Modular Society, 22 Buckingham-street, London, W.C.2. (TRAfalgar 4567.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

The Human Element

Lead a Horse to Water

Any hopes that Labour Party leaders may have had of appearing as the witch doctors of inflation have been rudely shattered by the Trades Union Congress. For some weeks now there have been attempts on the part of Mr. Harold Wilson, Labour's "shadow chancellor," to manoeuvre trade-union leaders into a position of close collaboration with their political colleages on the drafting of economic policy. The first signs of trouble appeared about a month ago, when the T.U.C. economic committee held a stormy meeting with the working party who are preparing a new Labour policy document on the control of industry. Mr. Cousins strongly objected to a suggestion that wage demands were the main cause of inflation. Now the T.U.C. economic policy committee have turned down a proposal from the working party that some of their members should attend working party meetings in a personal capacity.

The disagreement is a basic one, and it is a little surprising that Mr. Wilson should have thought it could have been resolved simply by closer personal contact between the two organisations. The T.U.C. do not accept that rising wage levels are in themselves a cause of inflation. Basic to their attitude is a belief that inadequate capital investment and a general lack of economic planning are the real villains of the piece. But even if they had inwardly argued that rising wages threaten full employment—and few of them would subscribe to this—they could hardly be expected to have meekly accepted a bridle and rider, however brilliant and acceptable as a political leader. The trade unions are jealous of their right to negotiate wage levels and working conditions on behalf of their members with whatever Government is in power, and in economic matters they take their cue from Dr. Erhard much more than from Mr. Wilson.

The T.U.C.'s list of recommendations to the Chancellor of the Exchequer this year, now being drawn up, is expected to include requests to reduce purchase tax and to encourage industrial expansion.

On the Waterfront

The two mammoth general unions have once more given their backing to a claim for a substantial increase in wage rates. Leaders of the Transport and General Workers Union and of the National Union of General and Municipal workers have agreed with representatives of the Watermen, Lightermen, Tugmen and Bargemen's union to present a claim to the National Association of Port Employers on behalf of the 100,000 dock workers they represent.

Details of the claim have not yet been released but it is unlikely to be more than the last increase, of about 5 per cent., paid out to them from May last year. Since then there has been a period of relative peace in the docks after a very stormy year. This latest claim will be a severe test of the Port Employers' negotiating skill, and also of the relations which now exist between them and the rank and file of the union membership. The National Amalgamated Stevedores and Dockers would be affected by any settlement of the claim though they are not associated with it. The interest in this development is the leading part played by the T. and G.W.U., Mr. Cousin's union. There could be few battle grounds more favourable to organised labour.

Worthy But Not Too Worthy

Training in the steel industry has grown to such organised proportions that the magazine devoted to it and issued three times a year by the British Iron and Steel Federation has been given a more ambitious format. The Federation's standard in this kind of venture is high, both as regards appearance and content. It will be of interest therefore to see whether the same quality can be maintained in a field of industrial publicity where others have tried before in fairly large numbers and have usually fallen foul of the two main traps—undue worthiness and dullness. The new layout has a refreshing appearance and the articles are varied in appeal. The iron and steel industry was one of the first big industries after the war to give training a key and adequately organised position in its corporate activities. Its re-styled *Training* (as the magazine is called) is therefore already appealing to something of a conditioned audience.

Foreigners are Human

The latest circular on visits abroad put out by the Central Bureau of Educational Visits and Exchanges (which is recognised by the education authorities in this country) underlines once more the large amount of time and organisation which is spent arranging visits, especially of young people, to and from foreign countries. Each year large numbers of young people cross national frontiers to see historical monuments, visit in foreign homes and take part in conferences and cultural exchanges. This is all in addition to the growing volume of adult touring abroad.

There is a strong dash of idealism in this kind of thing. We travel, so we are told, to broaden our outlook and to learn in modest degree that foreign people are normal human beings with a point of view. To some extent this is so, though it could also be argued that travel hardens our prejudices and confirms our insularity. Nevertheless, travel does open up new avenues of communication between individuals and may do some good to reduce mass prejudice against foreigners.

Whatever it may do, travel is on the increase due to the rise in the standard of living in Western Europe. In this country, young people are disinclined to look on the seaside as a place of annual family pilgrimage. They have money enough to go further and the abominable British summer adds impetus to their urge to get away. Foreigners, being such, take a different view. English fog is a tourist attraction—in small doses.

Epitaph for an Idea

A booklet called *Positive Employment Policies* has been sent by the Ministry of Labour to 15,000 employers. It is not being put on sale but is available to all who are interested in good human relations in industry. The booklet contains a foreword by the Minister, Mr. Iain McLeod, and gives a number of cases of what are in his opinion examples of good labour relations.

This type of exhortation by good example has many advantages in the short run. It ruffles no feathers. It mounts no attack on powerful vested interests. It is a reasoned appeal to reasonable men—and that is a good deal. One consequence of this kind of approach is that the examples chosen are somewhat "spotty" and show that there are as many different kinds of approach to such difficult questions as redundancy as there are concerns who try to tackle it. As a method of approach it is very similar to the idea of circulating average cost figures to members of an industry to show them how their efficiency compares with other concerns in the industry.

In one sense, the booklet is the sign of a retreat from a much more ambitious idea. The Minister has been favourably disposed for some time to the idea of the service contract for employees (which was part of the Conservative Industrial Charter). The idea of enshrining such a concept in legislation has been abandoned and the idea of the booklet takes its place. The Minister has decided that the path of progress must be by exhortation and good example.

Absence Makes the Workmen Ponder

The pit consultative committee of the Bentley Colliery, near Doncaster, recommended the dismissal of ten surface workers "for persistent absenteeism." At first it was thought that their decision had been approved by the local branch of the National Union of Mineworkers, but the men later claimed that this was untrue. A strike resulted, but it appears that the dismissed men have in fact left. Normal working was not restored until the miners had passed a resolution that their representatives on the pit consultative committee take no further part in decisions against absentees. The incident is a blow to what seemed to be a new and enlightened approach by the men to problems of production, but it may only be a temporary relapse.

Increasingly there is a tendency for organised labour to rid itself of "undesirables." There is emerging in coal mining a situation where more is being produced than can be sold. Miners may well feel that the time has come to tighten up their own ranks and make an all-out effort to reduce costs. Perhaps it was with this in mind that the chairman of the North Eastern Divisional Coal Board, Mr. W. H. Sales, told the industry that he does not believe in a "get tough" policy although he is disturbed by rising absenteeism. The statistics for January of this year show that there has been a 6 per cent. increase in absenteeism among the 55,000 surface workers compared with January, 1957.

The Coal Board must have derived considerable satisfaction from the initial attitude taken by the representatives of the Bentley Colliery workers on the consultative committee to those who continually absent themselves. As always, those who know best the failings of particular people, are their comrades or colleagues. The action of the joint consultative committee in this instance could transform the situation more quickly and more completely than anything the National Coal Board could do.

No Kidding

There is no limit to the ingenuity of the sales stunt men. One of the David Brown companies recently held a competition for children in which they had to place in order of merit the most important sales features of one of the company's products. The prize was to take away from a shop as many toys as could be carried—those dropped being returned to the counter.

So far as the children were concerned, there was a certain amount of skill involved. First there was the task of getting the points in order—quite a test of intelligence (or so the sales department would no doubt insist against sarcastic comment from the production side). Then there was the question of enterprise so far as taking away the toys was concerned. Three boys were the winners. Presumably they practised carrying toys around before they entered the contest. The final bouquet must be for the publicity "boys." The total haul by the three youngsters amounted to £73, a comparatively modest outlay for a novel and no doubt successful sales campaign. Publicity may sometimes seem frivolous in its approach, but often its practitioners (with an intention far from childish) reveal a keen understanding of public idiosyncrasy—kids' stuff, but no kidding.

Atomic Review

Continuous Process

In continuing his review of the B.N.E.C. papers on fuel processing, Mr. G. W. K. Ford discusses three problems germane to the chemistry of fissile materials: the disposal of fission wastes, the hazard of inadvertent criticality in chemical plants (a subject with which Mr. Ford is himself concerned), and the aqueous homogeneous reactor. Reactors of this kind, in which fuel and moderator are in the form of a solution, are an attempt to apply continuous chemical processing techniques to reactor design. The two-zone breeder reactor, a more complex version of the aqueous homogeneous system with a second fluid circuit for the breeding blanket, carries the principle a stage further. In some respects the complete plant is like a human circulatory system; the reactor is the heart and the chemical processing plant corresponds to the lungs, liver and kidneys, which serve to purify the circulating fluid and eliminate wastes.

The papers on which this account is based were presented at the British Nuclear Energy Conference's "Symposium on Nuclear Energy" held at Church House, Westminster, on January 21. Mr. Ford, who has prepared the summary, is research manager in charge of experimental criticality at the United Kingdom Atomic Energy Authority's establishment at Dounreay.

Fission Product Disposal

Arising from any of the aqueous-solution separation processes discussed in Atomic Review last week, 1 to 7 there is always a fission-product aqueous-solution raffinate, which presents a major disposal and utilisation problem. The paper by Mr. K. Saddington[2] provides a broad review of these problems and deals with current practices and future possibilities evolved and evolving both in this country and in the United States. It is of value to quote the following extract from the introductory section of the paper.

The Magnitude of the Problem.—In the United Kingdom we know that by 1965 the electricity generating capacity then installed will require the annual consumption of 6 to 8 tons of nuclear fuel (uranium 235) and this in turn will give rise to a similar amount of fission-product waste, the radioactivity of which will depend on the fission-product elements present, and on their age. In that year it is expected to produce fission products with an activity of 1,000 megacuries (10^9 curies) after 100 days "cooling." There is every likelihood that the annual production will increase in subsequent years. Globally, 50 to 100 times this amount may be produced annually by the end of the century. As an index of the toxicity of the fission products, it is calculated that 10^9 curies of fission products would have to be diluted with a million cubic miles of sea water in order to bring the concentration down to the level permitted in drinking water.

The Nature of the Problem.—The problem of radioactive waste disposal is finally solved only by the complete natural decay of the constituent fission product activity—a process which may take hundreds of years. The immediate problem therefore is that of holding the waste under safe yet economic conditions while such natural decay takes place. Available methods fall generally into two categories: (*a*) complete containment, which in principle consists merely of storage of the effluent under conditions of complete safety from the public-health standpoint until all or most of the activity has decayed; and (*b*) dispersion of the activity in such a way that, by natural or other causes, it is greatly diluted. The degree of dilution and the time in which it occurs must be such as to ensure that before the effluent is able to affect the public health or convenience by any means whatever, its activity has been reduced to insignificant levels. The figures indicated earlier in this paper undoubtedly show that this is not a complete solution, though it serves to dispose of large volumes of liquors of low activity, after removal of the bulk activity in some form of concentrate. Similar remarks apply to the disposal of large quantities of activity over land areas. In practice a combination of methods is used.

Nature and Classification of Liquid Effluents.—All current production-scale chemical processing of nuclear fuels is by solvent extraction and an essential aim of the processes used is the complete separation of the fission products from the fissile and fertile materials in the first extraction stage.[7] Since this separation is not quite complete, the fission products are split into a number of separate streams which are characterised primarily by the degree of activity of the stream, and possibly by its chemical nature. Table I illustrates typical streams arising from the present Windscale processes and broadly classifies them according to their specific activities, since these determine the choice of treatment to be used.

The paper goes on to consider the methods and approximate costs of treating each category of effluent and compares American techniques and costs with those developed in this country. For highly active effluents it is the United Kingdom practice to evaporate by a 200-fold reduction in volume followed by storage in water-cooled, concrete-shielded stainless-steel tanks. Although by water-cooling corrosion rates are kept very low, it is essential to maintain the stored effluent in liquid form so that, in event of a leak developing, the contents of the faulty tank may be pumped to an alternative store. Examples of the approximate costs of this process are given. One tonne of irradiated uranium might produce five cub. metres of highly active effluent. Evaporation to 200-fold concentration (at about £10 per cub. metre) would cost £50. Storage of the 0·025 cub. metre (at £100 per cub. metre) would cost £2 10*s*. Total cost: £52 10*s*. per tonne of uranium treated, or just over £10 per cub. metre of highly active effluent. This compares with £1 per cub. metre for the treatment of the neutralised medium-active effluent by absorption on to an alumina-floc blanket some 5 to 6 ft. in thickness. The contaminated floc is stored and the water arising is discharged to sea along with the low-activity effluent. At Windscale this is effected through a two-mile pipeline.

Costs for the disposal of low-activity effluent are not given, but there is an interesting discussion of the problems of making sure that this activity is not re-concentrated by living organisms to an unacceptable level or that it is not carried by currents or spray, following insufficient dilution, to places where it could become a hazard to the public. In fact it is found to be diluted immediately on leaving the pipe by a factor of 10^4. The paper closes with a short discussion of future problems, which emphasise the need to consider in great detail, during the design of the primary separation process, the raffinates produced from the process stages with a view to economy in subsequent fission-product processing and storage or disposal operations.

TABLE I *Origin of Main Effluents*

Source	Activity of waste effluent		
	High	Medium	Low
Primary separation Extractor I ..	×	—	—
Extractor II ..	—	×	—
Uranium purification	—	×	—
Plutonium purification	—	×	—
Solvent washing	—	× or	×
Rod storage ponds	—	—	×
Laboratories, etc.	—	—	×

Classification of Effluents

Type of effluent	Range of beta gamma activity per litre of solution	Daily arisings (gallons) Windscale 1956
Highly active ..	1—greater than 100 curies	Thousands
Medium active ..	Tenths—1 curie	Many thousands
Low active ..	Trace levels—fraction of a millicurie	Millions

TABLE II *Minimum Critical Conditions, Aqueous Solutions*

Fissile materials	Mass (gram)		Volume (litre)		Concentration (gm./l.)	
	American	British	American	British	American	British
Uranium 235*	800	780	6·3	5·6	11·6	11·0
Uranium 233	588	—	3·5	—	10·9	—
Plutonium 239	509	464	5·0	4·5	7·8	6·6

* ~ 90 per cent. uranium 235, 10 per cent. uranium 238

TABLE III *Basic Dimensions for Critical, Water-Reflected Solution Assemblies*

Fissile material	Sphere diameter (in.)		Cylinder diameter (in.)		Slab thickness (in.)		Volume (Litres)		Volume (Cub. in.)	
	American	British	American	British	American	British	American	British	American	British
Uranium 235* ..	8·9	8·5	5·0	6	1·4	1·9	6·3	5·6	380	340
Uranium 233 ..	7·3	—	4·0	—	~0·5	—	3·5	—	210	—
Plutonium 239 ..	8·3	8·0	5·4	5·1	1·9	1·6	5·0	4·5	300	270

* ~ 90 per cent. uranium 235, 10 per cent. uranium 238

Note: 1. These dimensions are the minimum for criticality for thermal neutron systems. An appropriate safety factor would have to be employed for design purposes.
2. The sphere diameters were calculated from the safe volume.

Nuclear Criticality

The process streams which contain fissile material have a special problem of their own in the form of potential inadvertent nuclear criticality; a paper on this subject was presented at the symposium by Mr. C. M. Nicholls and Dr. A. H. C. P. Gillieson.[3] In the processes already reviewed the fissile materials have been natural or slightly enriched uranium and pure plutonium, either in organic solvent solution or in aqueous solution. In other plants, uranium highly enriched in uranium 235 (the fuel having originated from a diffusion plant), or the artificial uranium isotope U233 (bred from fertile thorium in a breeder reactor), will be processed. Both organic and aqueous solvents are rich in hydrogen which is an excellent neutron moderator. If at any stage in the process the concentration of fissile material exceeds a certain minimum value (say, in the case of plutonium 6·6 gm. per litre of water) it would be possible for a nuclear chain reaction to be initiated given a suitably shaped and sufficiently large process vessel. Stronger solutions could become critical in smaller vessels, but provided either the solution strength or the vessel volume or the total mass of fissile material is kept below the figures given in Table II such a reaction cannot commence.

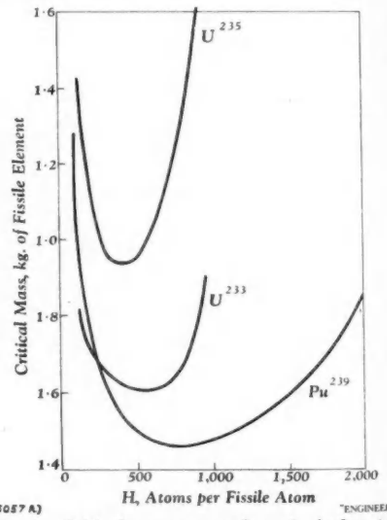


Fig. 1 Critical mass curves for spherical systems containing solutions of fissile materials in water (temperature 20 deg. C.).

The paper gives a brief description of why a chain

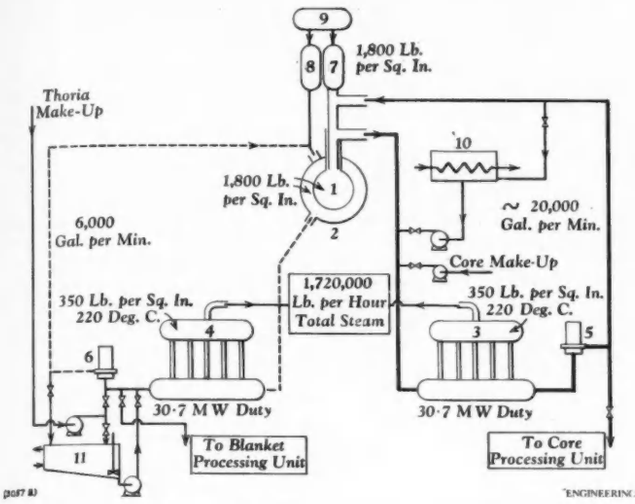


Fig. 2 Simplified flow diagram of a 100 MW (electrical) two-zone aqueous homogeneous breeder reactor design study, prepared at the Atomic Energy Research Establishment, Harwell.

1. Core
2. Blanket
3. Core-circuit heat exchanger
4. Blanket-circuit heat exchanger
5. Fuel circulating pump
6. Slurry circulating pump
7. Core surge tank
8. Blanket surge tank
9. Pressuriser
10. Main core dump tank
11. Slurry dump tank

reaction is possible, dealing in qualitative terms with the neutron or "reactor" physics considerations.[8] Emphasis is placed upon the desirability of designing a plant as far as possible to be inherently safe against the criticality danger by the proper choice of geometrical shape for the process vessels such that criticality is impossible under all plant operating conditions. With proper reservations, provided the dimensions of process vessels are kept below the sizes given in Table III, this can be achieved.

The reservations refer to such matters as that no reflector better than water (for example, graphite) be present; that if there are other vessels or pipes containing fissile material in the vicinity these should either be screened from the other vessels by neutron-moderating-absorbing material of sufficient thickness or there must be a sufficiently large distance of separation between vessels; that the temperature is not substantially below 20 deg. C.; and that the fissile material must be homogeneously dispersed throughout the plant vessel. Departures from these conditions will involve special arrangements or larger safety factors.

cannot occur. Additional information on plant criticality has been published elsewhere.[10]

Aqueous Homogeneous Reactor

The remaining paper in the symposium, presented by Mr. I. Wells and Dr. E. Lofthouse[4] dealt with the integration of the chemical processing plant and the power-producing reactor into one continuous system. A simplified flow diagram of a 100 MW (electrical) two-zone breeder reactor design study, prepared at the Atomic Energy Research Establishment, Harwell, appears in Fig. 2. It could almost be viewed as a chemical plant with a "swelling," the reactor core, formed at the appropriate point in the processing circuit, in which the fuel is allowed to achieve a self-sustaining nuclear chain-reaction, that is criticality, in order to produce heat and neutrons, from which products of the dual-purpose reaction, mechanical power and the transmutation of fertile material into further fuel may be derived.

The core-solution solvent-moderator-heat-transfer-agent would be heavy water (in a breeder-reactor), and this entails considerable complications in the processing plant on account of its great cost and the consequent need to minimise process losses. The paper mainly considers one particular homogeneous reactor scheme, namely the two-region breeder using uranyl sulphate (uranium 233) solution in the core and thorium oxide suspension in the blanket. This system has already been described in some detail.[11]

Chemical processing for this reactor entails essentially, in the core circuit: (*a*) removing gaseous fission products (by radiolytic gas purging), (*b*) removing insoluble corrosion and fission products (by fluid cyclones, made of titanium for wear resistance), (*c*) removing soluble corrosion and fission products (either by means of a deuterium-peroxide uranium precipitation process in heavy water, as indicated in Fig. 3, or a solvent extraction process in light water), and, in the blanket circuit, (*d*) separating the uranium 233 and protoactinium from the thoria (by removing the thoria from the heavy water, using heavy steam drying, dissolving in light-water solution and processing by solvent extraction), thus providing fresh fuel for the core. Fig. 4 shows a proposed circuit for thoria slurry and core solution take-off, and Fig. 5 a flow diagram for the external chemical processing circuit.

The attainment of a positive breeding gain in this reactor scheme depends critically upon the continuous removal of neutron-absorbing poisons from the core-blanket system. The chemical processing features are therefore of paramount importance to the economics of the system, entailing ingenuity of approach to the outstanding problems. In the words of the authors "It will be some time before such reactors are applied commercially since many problems still have to be overcome, problems largely associated with the containment of fluids, the handling of slurries, and the maintenance of equipment in high radiation fields. This is a fascinating field for study with plenty of scope for the application of new and novel ideas."

REFERENCES AND FURTHER READING

(The first six references refer to the B.N.E.C. symposium.)
[1] C. M. Nicholls, "The Development of the Butex Process for the Industrial Separation of Plutonium from Nuclear Reactor Fuels."
[2] K. Saddington, "Fission Product Disposal."
[3] C. M. Nicholls and A. H. C. P. Gillieson, "Nuclear Criticality—A Novel Factor in the Design and Operation of Chemical Plants."
[4] I. Wells and E. Lofthouse, "Fuel Processing in Homogeneous Aqueous Reactors."
[5] J. T. Wood and J. A. Williams, "Computation of the Performance of a Multicomponent Solvent Extraction System. The Separation of Uranium and Plutonium from Fission Products by Tributyl Phosphate."

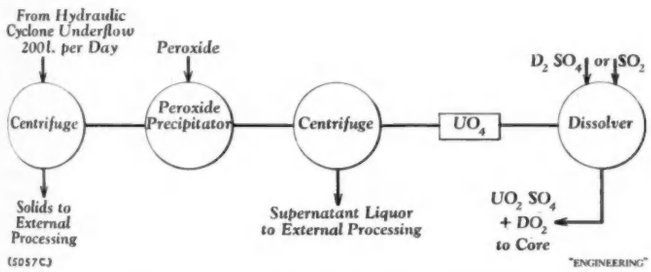


Fig. 3 (above) Arrangement of proposed peroxide precipitation process for removing undesirable soluble materials in the core circuit of a two-zone aqueous homogeneous reactor.

If geometrical limitation is not practicable it may be acceptable to impose operational limitations. An example is the control of solution concentration in relation to plant vessel volumes by means of experimental data such as that given in Fig. 1, using appropriate safety factors.

The foregoing considerations, along with many others dealt with in the paper, may strongly influence the selection of a chemical processing method for future separation plants. For example, a process in which no neutron-moderating agent is employed would allow much larger masses of fissile material to be present at any given stage of the process. The example is given of the extraction of plutonium from melted irradiated uranium by molten magnesium, followed by distillation of the magnesium-plutonium alloy to yield metallic plutonium directly.[9] The paper does not give the critical masses of plutonium metal, but does give figures for 93·5 per cent. uranium 235 metal, the critical sizes for spheres of this material being 48 kg. (uranium 235) if unreflected, or 22·8 kg. (uranium 235) if reflected by an infinitely thick water reflector. This latter figure may be compared with 0·78 kg. (uranium 235) for the water-reflected water-solution case given in Table II.

A criticality incident, while it would not be anything approaching a "kiloton" nuclear explosion, might do considerable damage to plant or constitute a radiation hazard to plant operators. It is therefore imperative that preventive steps are taken at all stages in the evolution of the plant, from process selection to plant operation, to ensure that a criticality accident

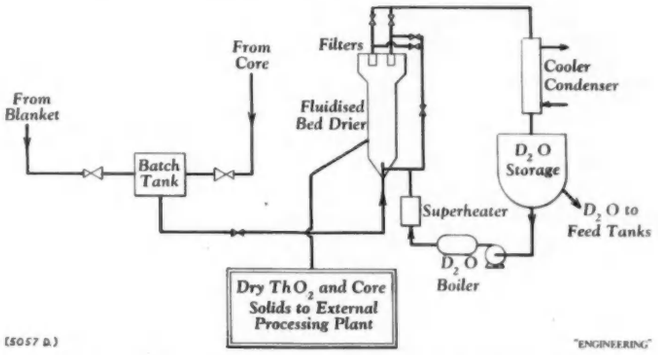


Fig. 4 Proposed circuit for thoria slurry and core solution take-off in the blanket of a two-zone aqueous homogeneous reactor.

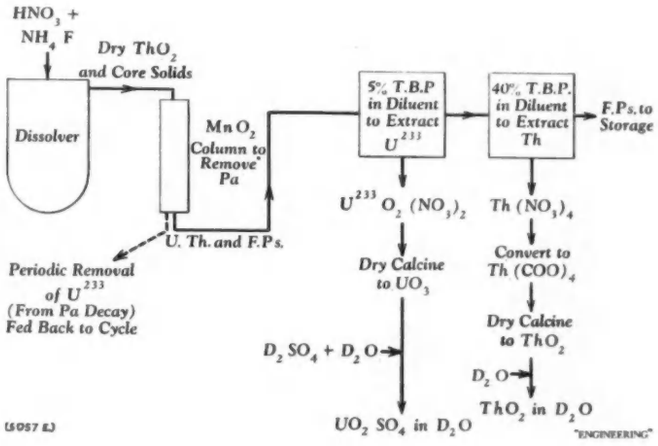


Fig. 5 (right) Flow diagram of external chemical processing circuit for a two-zone aqueous homogeneous reactor.

Continuing Atomic Review

[6] R. Galley, "The Marcoule Plutonium Plant."
[7] C. M. Nicholls and R. Spence, "Chemical Processing of Nuclear Fuels," *Journal of the B.N.E.C.*, vol. 2, No. 4, October (1957). See also Atomic Review, ENGINEERING, vol. 183, page 313 (March 8, 1957).
[8] G. W. K. Ford, "Physics in Reactor Design," ENGINEERING, vol. 184, pages 723, 756, 784 and 814 (December, 1957).
[9] E. L. Anderson, "Fuel Reprocessing: Fuel Reprocessing by Aqueous Methods," and "Low Contamination and Volatility Methods," *Nucleonics*, vol. 15, page 72 (October) and page 44 (December, 1957).
[10] D. Callihan, "Nuclear Safety in Processing Reactor Fuel Solutions," *Nucleonics*, vol. 14, page 39 (July, 1956).
[11] R. Hurst, I. Wells and D. Newby, "The Homogeneous Aqueous Reactor," *Journal of the B.N.E.C.*, vol. 2, No. 4 (October, 1957). See also Atomic Review, ENGINEERING, vol. 183, page 443 (April 5, 1957).
Sourcebook on Atomic Energy, S. Glasstone, paragraph 14.66 (Macmillan).
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Nuclear Chemical Engineering Benedict and Pigford (McGraw-Hill, 1957).

News and Notes

U.K.A.E.A. Change their Address

The United Kingdom Atomic Energy Authority will shortly move to 11 Charles II-street, London, S.W.1 (WHItehall 6262). The Authority's present offices in London will close on the following dates: 1 Richmond-terrace, S.W.1, on February 22; 14 Ormand-yard, St. James's, S.W.1, on February 22; Bedford-chambers, W.C.2, on March 1; and St. Giles-court, St. Giles High-street, W.C.2, on March 8.

New Director for Baghdad Centre

Mr. H. A. C. McKay of the Chemistry Division, Atomic Energy Research Establishment, Harwell, has been appointed Director of the Baghdad Pact Nuclear Training Centre from July, 1958, in succession to Mr. W. J. Whitehouse.

The Baghdad Nuclear Training Centre (see Atomic Review, April 12, 1957) was established in 1956 by the member countries of the Baghdad Pact. In its early stages it is concentrating on the practical applications of radioisotopes to the problems of Middle Eastern countries and is organising intensive short courses in the uses and techniques of these materials. Two instructors each from Iraq, Iran, Pakistan and Turkey, were trained at Harwell during 1956, and the United Kingdom also assisted by the gift of equipment and the seconding of Authority staff to supervise, teach and promote the development of the centre until local staff were sufficiently trained to take over responsibility. The first director of the centre, Mr. W. J. Whitehouse, was seconded from Harwell and went there in 1957 with four other members of the Authority staff to prepare the centre, supervise the installation of equipment provided from the United Kingdom and to organise and assist in running the first course. The centre was formally opened by His Majesty King Feisal II on March 31, 1957, when Sir John Cockcroft was elected first chairman of its Scientific Council.

Industrial Group Appointment

The United Kingdom Atomic Energy Authority have appointed Dr. H. Kronberger, O.B.E., F.Inst.P., to be Director of Research and Development in the Authority's Industrial Group. Dr. Kronberger is to succeed Mr. L. Rotherham, M.Sc., M.Inst.Met., whose appointment as a member of the Central Electricity Generating Board was announced in Atomic Review last January 10.

Reactor Risk Legislation

The Government is said to be preparing legislation to license and inspect nuclear reactors in Britain as a precaution against danger to the public. The reactor owner is to be liable to a maximum payment of £5 million in compensation for damage to property or person by radio-active contamination as a result of any one incident. There is a further reservation where contributory negligence is concerned. A reactor owner will be required to insure his liability or to show that he is holding adequate liquid assets. A liability in excess of £5 million will be regarded as a major national disaster in which it is customary for the Government to alleviate cases of hardship. The Government has been assured that cover will be available from the insurance market, which will deal with reactor risks through a pool, already in existence, including most of the insurance companies and Lloyd's. The coverage is limited to radiation injury and to land-based installations. Reference to the recommendations of the British Insurance (Atomic Energy) Committee, which have been closely followed, was made in Atomic Review last July 5.

Welsh Inquiry

A public inquiry into a proposal by the Central Electricity Generating Board to build a nuclear power station on the shores of an artificial lake in North Wales has opened at Trawsfynydd, Merioneth. The 500 MW station, if authorised, is expected to be commissioned in 1963. Local people are strongly in support of the project.

I.A.E.A. Plans

The Board of Governors of the International Atomic Energy Agency in its series of meetings held in Vienna between January 13 and 21, 1958, dealt mainly with technical problems and further developed plans for the early implementation of certain major tasks of the 1958 programme of the Agency. The board took measures to ensure that member states should receive immediately all necessary information about the fissile and other materials at the Agency's disposal, with a view to enabling them to develop their own atomic energy programmes and to apply for such materials. While it is unlikely that the Agency will stock-pile material during the early stages, more stress will be placed on developing machinery, enabling it to act as broker and to ensure the continuity of supplies. The Agency will also undertake studies in the near future concerning the need for reactors of various types in the economically under-developed areas of the world. The board gave much attention to the Agency's programme for exchange and training of scientists. The United States of America and the United Kingdom indicated that they would make substantial voluntary contributions towards the Agency's 250,000 dols. Fellowship Programme. Notifications were given by Poland, Roumania, the U.S.S.R., the United States and Yugoslavia that they would place fellowships and training facilities at the Agency's disposal in their own countries, which would be additional to the Agency's fellowship programme mentioned above. The Agency will also undertake a study regarding the possibility of establishing a Regional Training Centre in Latin America, and the board considered measures to enable the Agency to call upon Scientific advice from external sources, including the possibility of setting up standing or *ad hoc* advisory committees. The next series of meetings of the Board of Governors is scheduled to begin on March 10, 1958, and it has been decided that this series will be concerned largely with further details of the implementation of the Agency's 1958 programmes as well as with a preliminary discussion of projects for 1959.

Offers Received by I.A.E.A.

The offers officially communicated to the International Atomic Energy Agency up to the end of January, 1958, for atomic energy programmes to be carried out under its auspices include source materials and fissile materials, radio-elements and special materials for reactors, and fellowships and training facilities. The offers of materials come from nine member states: Canada, Ceylon, India, Norway, Portugal, Union of South Africa, Union of Soviet Socialist Republics, United Kingdom and United States of America. The prices and conditions on which the materials are to be made available to the Agency have yet to be determined. The source materials and fissile materials will for the present remain under the control of the countries of origin, and will be delivered only after agreements have been concluded between the Agency and the member states concerned. In a number of cases the offers were made in general terms, and the Agency is obtaining further details. Member states have been informed of the offers received, which are summarised below.

Canada has informed the Agency that, for several years at least, it could provide the amounts of natural uranium necessary for atomic energy programmes carried out with the participation of the Agency. Ceylon will make available to the Agency 30 tons of refined monazite of about 9 per cent. thorium content. India has informed the Agency that it could supply all the thorium necessary for atomic energy programmes carried under the auspices of the Agency. Norway has offered to supply isotopes produced in the Norwegian reactor at Kjeller, which is operated in collaboration with the Netherlands, and special reactor materials such as niobium, aluminium and molybdenum. Portugal has offered to make available to the Agency 100,000 kg. of uranium oxide in concentrate form. The Union of South Africa has offered to supply uranium oxide concentrates, subject to its prior contractual obligations. It is also prepared to consider the supply to the Agency of beryllium, lead, tantalum, cadmium, lithium, vanadium, chromium and nickel. The U.S.S.R. has offered 50 kg. of contained uranium 235 in any concentration up to 20 per cent., and is prepared to make available further supplies of fissile and other materials.

The United Kingdom has offered 20 kg. of contained uranium 235. The United States of America has offered 5,000 kg. of contained uranium 235. It will also make available nuclear materials equal in quantity to the total amount of such materials supplied by other Members of the Agency, and on equivalent terms, up to July 1, 1960. The United States has announced its intention of presenting the Agency with the gift of a technical library.

French Thermonuclear Studies

It has been reported that temperatures of a million deg. C. have been attained in France using a toroidal apparatus known as Equator. Reference to a large straight discharge apparatus under construction at Fontenay aux Roses, near Paris, appeared in Atomic Review last February 7.

Thermonuclear Studies in Japan

It is understood that temperatures of the order of a million deg. C. have been attained in thermonuclear apparatus at Osaka University in Japan. Detected neutron emission is said to be higher than was obtained in Zeta; 5 million as against 3 million per pulse. The Osaka discharge tube is stated to be smaller than Zeta and to have cost one-tenth as much; it is understood that the pulses were produced using a voltage of 85 kV with a current of 1,100 kA. The experiments have been directed by Professor Minoruk Okada, who believes that temperatures of 2 million deg. C. may have been obtained and that 5 million deg. C. are possible using the same apparatus. There is no conclusive evidence that the neutrons detected were thermonuclear in origin.

Second Thoughts on Fission and Fusion

The hazard of speculation may be particularly serious where revision of an industry may be involved, and the paragraph "Implications of Zeta" published in Atomic Review last February 7 might well prove to be misleading. The upheavals—however remote—that may accompany any reorganisation of the atomic energy industry may have repercussions in the present. For at least 20 years, therefore, it may be profitable to regard thermonuclear power much as America regards fission power to-day—as a prospect to be studied in detail and on a large scale, but only to be applied to supplement existing power sources when a really efficient plant has been developed. In 10 or 15 years, it may be convenient to regard our fission power stations as America now regards conventional plant, cheap and sufficient to meet all current needs. After all, even in Britain we are still building coal-fired stations.

The problem of planning and uncertainty is treated at length in our Leading Article on page 225. It is possible that the situation will be fully clarified at the Harwell conference in June, referred to in Atomic Review last week.

Companies in the News

B.E.A. Gets its Way

Last week negotiations opened between British European Airways and the Aircraft Manufacturing Company on the de Havilland DH 121. De Havilland itself will have a majority holding in this new company with Hunting Aircraft and the Fairey Aviation Company, also taking an interest. In addition Handley Page is to give help to the new consortium with technical advice based on its experience with high-speed aircraft and tail design. Rolls-Royce will develop the power unit.

The Government's approval to the negotiations was given by Mr. Harold Watkinson, Minister of Transport and Civil Aviation in a written answer in the House of Commons on February 12. Government approval is subject to the consortium comprising the new company being able to satisfy the Ministry that it has sufficient financial resources to develop the new aircraft entirely as a private venture. This point has in fact already been covered in an investigation by auditors. The Government's desire to use the B.E.A. contract as a means of rationalising the aircraft industry to some extent has therefore been partially achieved.

B.E.A. had already let it be known that it favoured the de Havilland design on technical grounds and it would have been exceedingly inept for the Ministry to have gone against the Corporation's wishes unless there were grave financial reservations. For the Government to have imposed its will on an airline would have involved its accepting full responsibility in due course if the new aircraft were to prove uneconomic or technically below specification. The order from B.E.A. is for about 25 aircraft which, including spares, will be worth about £30 million. The order will not itself allow B.E.A. to make a profit, and success in the venture so far as the consortium is concerned depends on selling abroad. The competition here is intense especially against the Boeing 720 but this problem would have to be faced no matter what combination of aircraft companies had undertaken the new project. The British consortium has two big advantages in the export field. It has the high reputation of the British aircraft industry behind it, and it is offering a new aircraft of high performance which can be used on staging routes. This is an attractive offer for a number of the big international airline companies.

Aerial Expansion

The 1957 annual report of the Radio Communication and Electronic Engineering Association published last week, reviews the activities of the telecommunications and electronics industry over the past year. The demand for most of the items produced by this industry continues to expand and is likely to continue to do so in the future. In addition to a flourishing domestic market both for defence and civil requirements, the industry has also gained a strong foothold in export markets. Overseas companies manufacturing telecommunications equipment are particularly well placed as a result of development plans in backward countries. Efficient communications between centres of commerce and trade are nearly always a prior consideration in such development plans.

Although there was a slight setback in exports of navigational aids and equipment in 1957, this is not thought likely to continue for long. The Russian market, however, may have been lost as a result of the restricted export list. Mr. F. S. Mockford, chairman of the R.C.E.E.A., referred last week to the Government's refusal to grant an export licence for the supply of mercantile marine radar equipment to the Soviets. The result has been, he said, that the Russians are producing their own radar equipment and are also reported to be exporting to China. Two markets are therefore being lost. This situation is particularly ironical when it is remembered that British produced H.F. long-range direction-finding equipment at Jodrell Bank was able to give Soviet scientists the exact route pursued by their Sputniks.

Among the interesting technical developments to which the R.C.E.E.A. report draws attention has been the installation of transistors in local communications equipment. This has enabled rural telephone systems to be extended in effectiveness without the expense and difficulty of carrying new lines, since it enables one telephone circuit to do the work of seven. Another interesting device outside the field of defence has been the echo-sounding equipment supplied to trawler fleets to enable them to detect the presence of shoals of fish with greater ease. Research is of course of major interest to the industry, which devotes some millions of pounds a year to its development. Several manufacturers have extended their research facilities, and guided missiles are of course a major research preoccupation. Many companies are also engaged on colour-television research, problems of forward scatter and the use of U.H.F. broadcast bands for communications and domestic sound and television broadcasting.

Mammoth of Brass

A new company—Yorkshire Imperial Metals Limited—have been formed by Imperial Chemical Industries to handle the copper and alloy tube, fittings and plate activities of I.C.I. and their newly acquired subsidiary, Yorkshire Copper Works Limited. The new company disposes of assets worth about £18 million, including the former I.C.I. plants at Kirkby (Liverpool), Smethwick (Staffs.), Landore (Swansea), and Dundee, and the former Yorkshire Copper plants at Leeds, Barrhead (Glasgow) and Castleford (Yorks).

This organisation is of a sufficient size to yield major economies of scale and considerable marketing strength. In the rolling and tube fields there is no other company of comparable size. On the contrary, the West Midlands are filled with dozens (not to say hundreds) of small firms and a few of medium size, rolling brass plate and sheet. Yet the problems that this industry faces require size to solve them. There are fluctuations in the price of copper, and the vital necessity to be in a position to bargain with suppliers. There is also competition from other metals, particularly aluminium. Great efforts are required to keep ahead in the technological race now developing, and substantial resources are required to do this effectively. The activities of the Copper Development Association show that there is a potential increase in consumption, but as could be expected after years of shortage, single-mindedness and a great deal of cash will be needed to realise this potential.

Machine Tool Complex

The machine tool position is lending itself less and less to prognostications. Nowadays conflicting trends in engineering manufacture generally make prediction a hazardous occupation. The latest figures for the machine tool industry show that production continues to run well ahead of new orders and that the industry's order book has fallen to its lowest point for three years. It also shows that in the home market the rate of new orders now seems to be levelling off. There are no signs that the industry has been affected to any major extent (in fact to none visible) by the intensified credit squeeze. Output has soared during the past year, to a total value of some £95 million, or £10 million more than the previous peak level reached in 1956. The performance over the year was very satisfactory from the point of view of the country's trade balance: exports rose by nearly 18 per cent. to £28 million, while imports fell by £3·8 million to £21·8 million (mainly from Germany and the United States).

An interesting commentary on the future of the industry was made by Mr. G. K. Galliers-Pratt, chairman and managing director of F. Pratt and Company, Limited, manufacturers of lathe chucks. Reviewing the company's prospects, Mr. Galliers-Pratt said: " the demands upon us continue to be more specialised and technical, with increasing calls for tools of high precision." For this reason they have sought to widen the range of their products. This is becoming general the world over, and is a trend already observed in other fields of engineering. There is a need to cater for the more specialised requirements of industry, and the whole business of making machines which sell well abroad will therefore tend to become more complex.

Other manufacturers are finding rising costs a serious threat to exports, particularly in competition with Germany. Butler Machine Tool anticipate a good year, provided costs can be held down and serious labour disputes avoided. Asquith Machine Tool Corporation take note of the unfavourable trend of orders and have greatly intensified their sales effort through their marketing company, Drummond-Asquith (Sales), within which a new division is being set up " to advise on the design, manufacture and supply of all types of heavy steel forgings, castings, vessels, plate and structures."

Britannias and Orions

The Governmental axe continues busily in the aircraft industry and it is good therefore in this time of crisis to read of the industry's outstanding achievements. Bristol announced recently that the Ministry of Supply had decided, " in present financial circumstances," to discontinue support for the development of the Bristol Orion turbo-prop engine, despite the fact that they remained " fully convinced of the intrinsic merits of the engine." The company in their turn decided that they were not justified " in the present general uncertainty about long-term requirements for long-range aircraft in this country " to continue the work as a private venture. Thus is missed at a critical time the vital next step in the development of the turbo-prop, a field where British aircraft are now so firmly in the lead.

Ironically enough, bearing the same date stamp, came a B.O.A.C. announcement reviewing the performance of the Bristol Britannia during its first year in passenger service. Already—almost, it seems, before the echo of the last words about icing of engines has died away—B.O.A.C.'s Britannias have carried 77,500 passengers and have flown some eight million miles during 28,000 hours in revenue-earning services. Nearly all this has been performed by 15 medium-range 102 aircraft, since the long-range 312 Britannias have only recently begun operations over the Atlantic. The services have been well patronised, and passengers are warm in their praise of the aircraft. A 72 per cent. average revenue load factor has been obtained during the year which is most satisfactory. To have aircraft in the air for 8½ hours a day on an average, and a daily utilisation of 6¾ hours for aircraft over the whole year, matches the best—that of the DC-7C aircraft introduced at the beginning of last year—and is better than any other in the first year of service.

This kind of performance suggests that world markets would be wide open to the British Britannias. Yet the company could not see their way to continuing development work on the natural successor to the Proteus 705 engine used in these aircraft. In this, as in other fields, political considerations tend to exert a growing influence on technical development.

In Parliament

PROTECTING CONSUMERS

Success in the parliamentary ballot enabled Miss Elaine Burton (Labour) to initiate a half-hour adjournment debate in the House of Commons last week on the consumer-protection services of the British Standards Institution. In her opening remarks, which began shortly after 11 p.m., Miss Burton referred to the three issues of the Institution's *Shopper's Guide* that had been published and asked if it were not the case that that magazine, and other periodicals of the same kind, could not make adequate comparisons for the general public because of the law of libel.

Later, she summarised the points raised in her address by asking the Parliamentary Secretary to the Board of Trade to examine the problem of quality standards in merchandise, to agree that the Institution should not be tied to waiting for a majority of manufacturers to agree to a particular standard, to publicise any industry and its manufacturers where co-operation with the Institution was refused, to look into the whole question of unofficial quality marks, and to give financial backing to the Institution should any legal action arise subsequent to the *Shopper's Guide* being available to the general public on the bookstalls. Lastly, she asked for an explanation of the position concerning the proposed merger of the Institution's Consumer Advisory Council and *Shopper's Guide* with the Association of Consumer Research.

VOLUNTARY STANDARDS BEST

In his reply on behalf of the Government, Mr. F. J. Erroll began by pointing out that the British Standards Institution, though aided by a Government grant, was an independent body, and itself responsible for the way it conducted its affairs. Outside subscriptions were very substantial.

The main Government grant was matched with industrial subscriptions in the previous year, subject to a maximum which was £130,000 in 1956-57, £140,000 in 1957-58, and £150,000 in 1958-59. Industrial subscriptions had been so high during the last two financial years that, as previously, the maximum grant had been earned. In 1957-58, the Institution was granted an additional £10,000 solely for the expansion of its work for the domestic consumer. This amount was not related to industrial subscriptions and, subject to parliamentary approval, another £10,000 would be granted in the same way and for the same purpose.

As to standards of quality, there was a general desire to see an extension of the Kitemark, but it would be a mistake to make the use of that mark compulsory and legislation would be required. The best way to bring about an extension of its use would be for customers to look for the Kitemark and to ask for Kitemark goods. Pressure would thereby be brought to bear on the retailers and, through them, on manufacturers. Compulsion in respect to consumer goods would be directly contrary to two important principles governing the Institution's highly successful work in industrial goods: that the use of its standards was entirely voluntary and that standards were issued only on a majority support from the parties interested.

THOUGHTS ON A MERGER

A suggestion had been made, Mr. Erroll continued, that the Board of Trade should publicise any industry which refused co-operation. What good would that do? Co-operation must, by its very nature, remain voluntary and it did not seem right that the Board should appear in the role of whipping boy, whipping reluctant industries into a form of co-operation which, for what might seem to them to be very good reasons, they did not wish to bring into being. As to the non-statutory marks issued by some private individuals and organisations, and to the so-called quality labels and certificates, there was a fairly definite legal position. Misleading claims to most of the ascertainable characteristics of goods, such as size, or fastness of colour, could already be dealt with under the Merchandise Marks Acts. Vague claims, however, such as "This is better" or "Something Else is Best" were not covered by existing legislation. Indeed, it was difficult to see how any legislation which did not unreasonably limit advertisers could be made to cover such vague claims.

With regard to certain proposals about the position of *Shopper's Guide* in the event of an action, it would be quite impracticable for the Board to guarantee the costs of any action which might result. That must be a matter for the judgment, discretion and good sense of the British Standards Institution itself. It was not fear of a libel action by manufacturers which prevented the Institution from putting *Shopper's Guide* on general sale. As a matter of policy, the Institution preferred to rely on direct distribution to associates.

On the question of a successful merger between the bodies mentioned, formal discussions had not taken place between the two organisations, and, Mr. Erroll said, it would be inappropriate for him to comment on an idea which was still the subject of preliminary discussion within each body. It might, of course, be that these discussions would lead to some new development.

LOST WORKING HOURS

The average time lost in 1957 on account of industrial disputes amounted to about three hours for each worker engaged in industry, according to an answer given by Mr. Iain Macleod, the Minister of Labour and National Service. He told Mr. Henry Hynd (Labour) that the latest estimates relating to the twelve months ended June 4, 1955, showed that, on an average, nearly one day was lost for each person involved on account of industrial accidents and diseases; and about 14 days for sickness benefit. The last figure, however, includes a substantial element of chronic sickness relating to people who have really dropped out of the industrial field.

NAVAL SHIPBUILDING

Attention was called by Captain H. B. Kerby (Conservative) to the length of time which certain frigates for the Royal Navy had been in the course of construction. Mr. Robert Allan, the Parliamentary and Financial Secretary to the Admiralty, replied that the aircraft-detection vessel, H.M.S. "Lincoln," one of the ships referred to, had not been laid down until June, 1955. An earlier start had been prevented owing to the prior claims of merchant shipbuilding on the shipyard concerned.

H.M.S. "Leopard," an anti-aircraft frigate, which was launched at Portsmouth Dockyard in May, 1955, was expected to be completed this year. Progress had been affected by the priority demands made on the dockyard's resources by the immense task of reconstructing and fitting out the aircraft carrier "Victorious."

It appeared that there had been no undue delay in the matter.

RAILWAY LINE CLOSINGS

Copies of the report of the Central Transport Consultative Committee on the proposals of the British Transport Commission to withdraw train services between Lewes and East Grinstead were made available on February 12. Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, pointed out, in answer to Mrs. Evelyn Emmet (Conservative), that the committee had concluded that, although the financial savings resulting from closing the line appeared to be considerably less than had been estimated, they were nevertheless substantial and that, in the public interest, the continuing losses could not be justified. The committee had recommended, therefore, that the line should be closed. They had also made recommendations regarding the information to be furnished by the British Transport Commission in support of future proposals to withdraw railway services.

The Commission had informed him, Mr. Watkinson stated, that the services between Lewes and East Grinstead would be withdrawn on March 17. In respect to future proposals for the withdrawal of services, the Commission had expressed their anxiety to find a satisfactory basis for the submission of supporting financial information. With that end in view, they intended to have early discussions with the committee on that subject.

Ship Sales Oversea

During the past five years, Mr. Watkinson said, 180 merchant ships, of 500 gross tons and above, had been transferred from the United Kingdom or colonial registers to registry in Liberia, Panama, Costa Rica, or Honduras. A suggestion was put forward by Mr. S. S. Awbery (Labour) that it would be far cheaper for such ships to be sent to the ship-breaking yards and to use the scrap for re-building, than to sell them to people who were competing against us in an unfair market. Mr. Watkinson replied that if the British shipping industry were deprived of its foreign market for the sale of second-hand vessels, it would be deprived of large sums of money that could be applied to buying new ships.

Solar Energy Research

Making direct use of the sun's rays as a source of power is a fascinating problem. Mr. Alan Lennox-Boyd, the Secretary of State for the Colonies, assured Sir Wavell Wakefield (Conservative) that he was aware that sun-powered furnaces, mounted on surplus military searchlights, were now available in the United States on a mass-production basis at prices which could be afforded by low-budget colleges. The demand by university or Government research establishments in colonial territories for such equipment was bound to be small, but, said Mr. Lennox-Boyd, he would bring developments in this field to the notice of those concerned, so that they might consider whether they could profitably acquire equipment of that type.

Noisy Motor Cycles

The Government are anxious to ensure that all new motor cycles are as silent as practicable. To that end, Mr. G. R. H. Nugent, the Joint Parliamentary Secretary to the Ministry of Transport, informed Sir Ian Fraser (Conservative), they had already arranged for tests to be carried out by officers of his ministry, to determine what standards should be set for the upper limit of noise by new motor-cycle engines. The tests were being carried out in collaboration with the manufacturers.

Scrap Iron Imports

Sir David Eccles, the President of the Board of Trade, told Mr. R. Reader Harris (Conservative) that 390,537 tons of iron and steel scrap, valued at £10 million c.i.f., was imported into this country from dollar sources during the twelve months ended December 31, 1957. Sir David added that, according to his information, no further imports were expected at present, apart from small arrivals carried over from last year.

B.E.A. Jet Airliner

British European Airways opened negotiations last week with a new company, in which de Havilland Aircraft Company Limited, Hunting Percival Aircraft Limited and Fairey Aviation Company Limited will participate, with a view to the placing of an order for a jet airliner. Mr. Watkinson told Air-Commodore Sir Arthur Harvey (Conservative) that Rolls-Royce Limited would develop and manufacture the required power plant. The Government, he explained, would wish to be satisfied that the whole project would be developed and produced as a private venture by the firms concerned.

Metals and Materials

WELDING—AND CRACKING

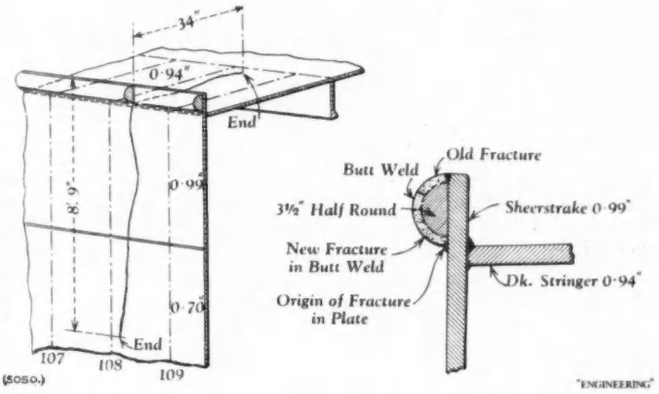
The development of shipbuilding methods and hull structural design is strongly influenced by the "feedback" of knowledge of defects which occur during the service life of ships. Of the various classification societies and kindred institutions that communicate this sort of information back to the shipyards, none is more ubiquitous than Lloyd's Register of Shipping. The Society's surveyors, all over the world, send in about 1,000 reports a week describing damage and accidents to ships.

In recent years, a system of analysing and indexing these reports has been established which now makes it possible to gather together all the relevant experience relating to a particular kind of defect occurring in a given type of ship, in a given set of circumstances.

A description of this system and some typical examples of the most common fractures which occur in the construction and service of welded ships were given by Mr. H. R. Gibbs and Mr. G. M. Boyd, of Lloyd's Register, in a paper presented to the Institution of Engineers and Shipbuilders in Scotland, in Glasgow on February 11. The title of the paper was "Welded Ship Construction—Records of Common Fractures and Their Causes."

The run of the mill experience with welded ships, which now form the bulk of new tonnage, is unsensational but cracks do occur from time to time in the hull structures. Riveted ships also have their troubles. Not only do cracks sometimes appear but there is also the problem of keeping the riveted joints watertight. The all-welded ship, however, has features which perhaps make it a little more "highly strung" than a riveted ship.

The heat of welding causes residual stresses to be built up in the hull structure. These stresses and strains are indications of the stored strain energy which may, under unfavourable conditions, cause a crack to propagate. The absence of any discontinuity in the structure also contributes to the possibility of crack propagation.



A crack present in a butt weld in a bar moulding triggered off a fracture which went nearly 9 ft. into a ship's shell plating and nearly 3 ft. across the deck.

A number of design and construction precautions are taken to avoid this background danger. For example, riveted seams are introduced into welded ships as "crack-arrestors," steels with a high resistance to brittle fracture are used, and so on. The most important practical precaution of all is to prevent cracks occurring in the first place.

An example of the danger existing in the continuity of the welded structure is shown in one of the authors' drawings, reproduced above. A half-round bar moulding was attached to the main shell sheer strake by welding. It appears that a crack was present in a butt weld in this seemingly trivial bar moulding. This crack, far from being trivial, suddenly triggered off a fracture which went nearly 9 ft. into the shell plating and nearly 3 ft. across the deck. A similar example occurred in a bilge keel welded to a flat bar, in turn welded to the side shell. A crack in a butt weld of the bilge keel caused a fracture in the main bilge plating 17 ft. in length.

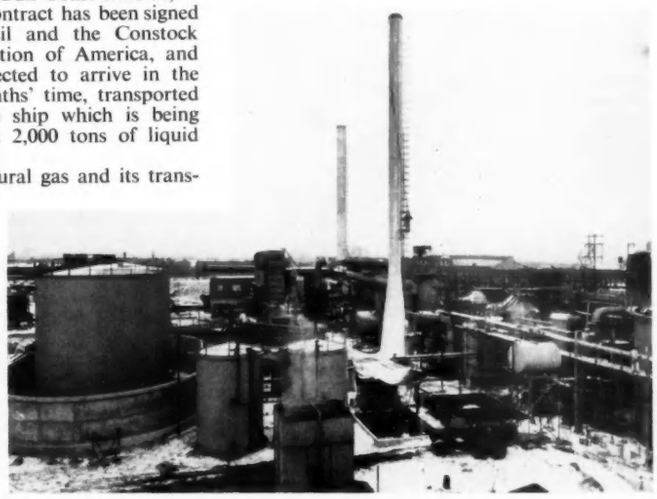
A common danger point is where different members intersect. One of the most troublesome of these junctions occurs when flat plates are butt welded together, at the point where the two perpendicular butt welds intersect. It is usual and desirable that if a series of rectangular flat plates are being butt welded together, the transverse welds on the short edges are made before the longitudinal welds on the long edges. The danger is that at the ends of the short butt welds, cracks or lack of fusion may exist. When the longitudinal weld is made, these cracks may extend, but, fortunately, if this happens they are likely to be detected during the construction period. Repairs of this sort of defect are difficult to achieve because the extent of the crack is often very much greater than appears on the surface.

One method of avoiding this type of defect is to use a run-off plate at the end of the transverse butt weld. This has its dangers too, because the run-off plate is frequently welded to the main plate. When it is removed there is a tendency to tear the main plate and to provide another stress raiser which might initiate cracking. Clamping is now advocated as the safest method of attaching run-off plates.

LIQUEFIED GAS FOR NORTH THAMES' MAINS

For some years past the Gas Council have been working out ways of using natural gas to supplement the supplies derived from the carbonisation of coal, a source which is steadily diminishing. As described in last week's issue of ENGINEERING (page 222), their scheme for utilising refinery gases from the Shellhaven oil refinery, piped to the Romford installation of the North Thames Gas Board, is now well under way and is expected to go into operation early this summer. Another possibility that is to be tried out during the coming year is the shipment of liquefied natural gas, in the first place from the Gulf Coast oilfields, to the United Kindom: a contract has been signed between the Gas Council and the Constock Liquid Methane Corporation of America, and the first shipload is expected to arrive in the Thames in about 12 months' time, transported in a jointly-owned cargo ship which is being converted to carry about 2,000 tons of liquid natural gas.

The liquefaction of natural gas and its transportation in the liquid form presents no easy problem, for methane, the principal constituent of natural gas, requires a temperature of — 260 deg. F. for liquefaction at atmospheric pressure and the material must be maintained under these conditions during transportation. When liquefied, however, the volume of the gas is reduced to 1/600 of the space it occupies in gaseous form. The technical difficulties of the liquefaction processes have, however, been largely overcome, and the storage of liquefied gases is well understood. What is new is the attempt to convey, by ocean-going vessel, fluids in insulated tanks at such extremely low temperatures, and it remains to be seen whether, technically and economically, this sea-borne transport gives the results which are hoped.



The catalytic plant now being built at Romford will transform methane (and waste refinery gases) into a form suitable for domestic use.

For the trial shipment, it is proposed to use an already existing liquefaction plant which has been constructed on a barge, and which can be transported to any site in the area at which the natural gas may be loaded. This plant has a capacity of about 8 million cub. ft. of natural gas a day. The liquefied gas will be stored in tanks on shore before being loaded into the vessel for shipment.

The vessel which is being converted for the trial load is a double-bottomed cargo ship about 340 ft. in length which, after conversion, will carry about 2,000 tons of liquid methane, contained in five tanks insulated with balsa wood. Their design and location will be such as to accommodate the effect of ship's movement at sea. As the liquid methane cargo is exceptionally light, the ship will be specially ballasted. The design and engineering work for the conversion is being handled by J. J. Henry and Company, New York marine architects, and the work is being carried out by the Alabama Dry Dock and Shipbuilding Company Inc. at Mobile, Alabama, U.S.A.

The marine terminal for the acceptance of the trial shipment in this country will be at Canvey Island, on land belonging to the North Thames Gas Board where there are suitable deep water facilities. Two 1,000 ton capacity storage tanks necessary to deal with the trial shipment are now under construction. The contractors for this work on behalf of the Board are the Whessoe

Continuing Metals and Materials

Company, Limited, Darlington, and A.P.V. Company, Limited, Crawley.

The liquid natural gas will be pumped from the cargo tanks on the vessel to the shore storage tanks by specially-designed ships' pumps through a pipeline with a 6 in. covering of insulation. Although these shore storage tanks are heavily insulated, there will be a continuous boil-off of gaseous methane from the liquid and this material will be contained in a small gasholder of the dry-sealed Wiggins type, whence it will be pumped into the mains system. Liquid methane will be vaporised by heat exchange with water or steam; at this stage there is no intention of making use of the cold content of the methane, but should the experiment prove fruitful, this refrigerating capacity—which is one of the economic attractions of the use of liquefied natural gas—will probably be utilised in low-temperature chemical processes. The liquid methane will be converted to gas under pressure and conveyed into the Board's transmission lines.

The town's gas supplied in the North Thames Gas Board is distributed at 500 B.Th.U. per cub. ft. while the methane has a calorific value of 1,000 B.Th.U. per cub ft.; transformation of the methane into gas of 500 B.Th.U. per cub. ft. will be carried out at Romford by the Onia-Gegi catalytic process. The catalytic plant which is to be used for the transformation can be seen in the illustration on the previous page.

NEW SPECIAL GREASES FOR BEARINGS

The combination of bentone grease and molybdenum disulphide known as Molytone grease, used for bearing lubrication, was replaced on February 1 by three new greases, called Molytone 265, 320 and 380. The makers, Rocol Limited, Rocol House, Swillington, Leeds, state that the first-named lubricant is suitable for general grease cups and ball and roller bearings of over 2 in. or 5 cm. in diameter and working at speeds up to 2,000 r.p.m. The No. 320 grease has been developed for pressure systems, automatic lubricators and ball and roller bearings of under 2 in. diameter, and working at speeds of over 2,000 r.p.m. The Molytone 380 lubricant is an ultra-soft grease for high speeds of over 10,000 r.p.m. and for precision work, instruments, servo motors, gyros and all lightly-powered mechanisms. The working temperature range of all three greases goes up to 230 deg. C., and down to — 20 deg. to — 40 deg. C., according to the lubricant.

RUST-INHIBITING PAINT

The manufacture, properties and applications of Rustodian rust-inhibiting calcium plumbate paint were outlined in a colour cinema film shown in London recently. The chemical structure of calcium plumbate, $2CaO.PbO_2$ is similar to that of red lead (or lead ortho-plumbate), namely, $2PbO.PbO_2$. The new pigment, which is produced and marketed by Associated Lead Manufacturers Limited, Ibex House, Minories, London, E.C.3, is stated to inhibit rust because it forms a protective layer over the cathodic as well as the anodic areas of a steel surface. The film shows the excellent qualities of adhesion of the new paint as a primer for most metals and, perhaps most remarkable of all, for new unetched galvanised work. Rustodian is stated to have 8 or 9 times the life of standard rust inhibitive paints under sea-spray exposure. The natural colour of the pigment is light stone and the paint is also supplied in peach, light Brunswick green, dark battleship grey, imperial brown and Venetian red. It is available in all the usual packages from ½ pint to 5 gallon drums.

Marketing

SENDING MACHINES AND SPARES BY AIR

*By A. J. Weight**

Some details published last June by the Board of Trade on United Kingdom exports and imports show that the value of machinery exported by air from Great Britain now holds second place in importance of all products carried by air. (Pride of place is held by the very highly valued precious-metal class.) Like many statistics, the Board of Trade figures do not show all the picture, and in this particular context it might be more indicative if uplifted tonnage were also given.

In the experience of K.L.M., one of the most significant factors in the development of air freight to and from this country since 1946 has been the steady annual rise in machinery exports —not only large industrial machines, but also spares, auxiliary attachments, etc.

In the engineering industries, there is now an increasing interest in the possibilities provided by world-wide air-freight services since competitive conditions compel consideration being given to a fast, reliable and (taking hidden costs into account) often cheap transportation method. Since 1945, many companies have invested heavily in overhauling and modernising their plant to cope with production demands, and to develop new techniques. Those companies who anticipate future development cannot still subscribe to old-fashioned transportation methods. However, whether air freight is the answer depends to a large extent on variable factors important in the engineering field. The points to be considered are:—

Is the finished product of such a weight and size that the aircraft operating to-day are capable of handling it? What are its spares needs? What is the selling value of the product and the costs to have it air-freighted? Is the customer abroad using the product to produce other goods? Is there, therefore, a financial advantage to be gained by having the machine in service that much quicker? Are the overseas markets served by sufficient air capacity to meet the manufacturers' needs? By accepting air transport as part of the production system, can expensive backlogs in the factory or additional emergency production costs be avoided?

To offset the conservatism that still exists on a large scale, the major cargo-conscious airlines have taken steps to encourage the opening-up of the engineering market utilising air transportation, by introducing, on the main trade routes, specially-reduced rates for various types of machinery and equipment. Although the response has probably been better than originally anticipated, the current feeling is that far more can be done. But the active co-operation of managements in the export/import field is very necessary.

Already appreciated are unpacked movements combined with very low insurance rates, and the advantages of speed of delivery for the customer abroad. But the so-called hidden savings, allied to export financing, plus the reduction of the necessity to maintain large stocks abroad—for a telegram from the stockist abroad to the manufacturers can result in the item needed being sent within 24 hours—are not yet fully realised.

For the manufacturers of small to medium-sized machines and products, figures can be produced to show that air freight is not as costly as some of the airport-to-airport rates might suggest at first glance. To cities within a few hundred miles radius of the United Kingdom international airports, very low rates for some types of machinery have been available for a long time and are being extensively used. In addition, these rates offer costs very competitive with rail/sea carriage. On long-haul stretches, as facilities and capacities improve, there is no doubt that the average haul of machinery and spares will go up. To-day, machinery is a main commodity over the North Atlantic in both directions.

To cite a couple of instances: a manufacturer of precision engineering apparatus has proved for himself that by fully incorporating air freight in his production scheme and by cutting out expensive storage abroad, it is more profitable to ship by air over a radius of 4,000 miles. Another exporter of precision machinery, who wished to air-freight the finished commodity, called in an air-freight salesman at the design stage. According to the plans, the machine was just too big for the width of present aircraft hold doors. The design plan was subsequently slightly altered to conform with loading requirements—an outstanding example of co-operation between manufacturer and transportation company.

Another point: many companies are unaware of their own total packing and transport costs. And the amount of money that can be saved by cutting down on packing when using air freight is remarkable. In some special cases, the gross weight packed for export by surface transportation is more than 200 per cent. above the net weight of the article itself. In reducing packing material and labour costs, the manufacturer can reduce his selling price abroad and thus improve his sales in competition with other nations.

* Freight Sales Manager, K.L.M. Royal Dutch Airlines.

MARKETING BY RENTING

There appears to be no limit to the expansion of the business of those who can offer radio and television sets for rental at an economic figure backed by first-class service. Mr. P. Perring-Thoms, chairman and managing director of Radio Rentals Limited, announced a record profit of £1·32 million for the year ended at August 31, an improvement of nearly £300,000 on the previous year's performance. This increase in profits he said is due " primarily to expansion and improved efficiency and not to any increase in profit margins." In view of the mounting costs in this type of business the improvement in efficiency must have been considerable to maintain margins at their former level.

One of the main factors in Radio Rentals' prosperity is the boom in television renting. The impact of the Control of Hiring Order has continued to restrict the radio side of their business, but Mr. Perring-Thoms said that this has not been so in television because a larger percentage of the public prefer to rent television sets than was the case with radio during its years of expansion, " due no doubt to the general recognition that television sets can be very expensive to maintain by individuals."

The company " look to the future with confidence," the chairman states. One of the factors in the group's ability to keep costs down reflects with significance on the progress that has been made in radio manufacture since the war. Mr. Perring-Thoms said that " the increased supply of first-class receivers " made by Mains Radio Gramophones, which are designed " not only for ease of maintenance but also for superior performance," has been an important factor in the group's growth. The first three months of their current financial year " continued to be satisfactory " and there appears little reason to doubt that the company's expansion will continue.

construction

ACCELERATED CURING TESTS ON CONCRETE

Port of London Authority's 7 Hour Site Test

By N. N. B. Ordman, B.SC., A.M.I.C.E., *and N. G. Bondre*, B.SC., PH.D.

The importance of the quality control of concrete, not only because of the need to produce a high-quality structural material but because of the resultant savings, is nowhere more clearly realised than by those responsible for maritime works, where conditions frequently exist which rapidly expose inferior concrete, usually with costly and sometimes with disastrous results. Decisions regarding methods of control must stem from considerations of the design and specification of the mix. It is in the latter that a basic difficulty arises.

Concrete is unique among building materials in that, in common practice, not only are the required characteristics specified but also the methods to be adopted by the contractor to obtain them. The paradox that manifestly exists in this situation is widely recognised, but for various reasons the situation is permitted to continue. Engineers have not decided that in general they can safely leave the manufacture of concrete to their contractors in the same way as they leave the manufacture of steel to the steel maker and, strangely enough, contractors have themselves tended to prefer the existing system. Nevertheless, it would seem that the most logical and economical approach would be for the engineer to specify his requirements in terms of strength, hardness, etc., and for the contractor to determine the proportions of the ingredients and decide upon the method of manufacture, and it seems probable that this approach will be more and more often applied.

With the present practice of specifying both the strength requirements and the means of producing them, site control must include means of testing the strength of the concrete produced and the need for such tests will be even greater if the practice of specifying strength only becomes more general. However, under the present and possible future conditions, a strength test at 7 or 28 days is not enough. It is necessary that the test results be available sufficiently quickly to enable unsatisfactory concrete to be rejected before so much of it has been placed and set as to render its removal a costly and time consuming operation. Another reason for early information is the site adjustment of basic mix proportions which is frequently necessary and can only be tentative until its validity is confirmed by actual test results.

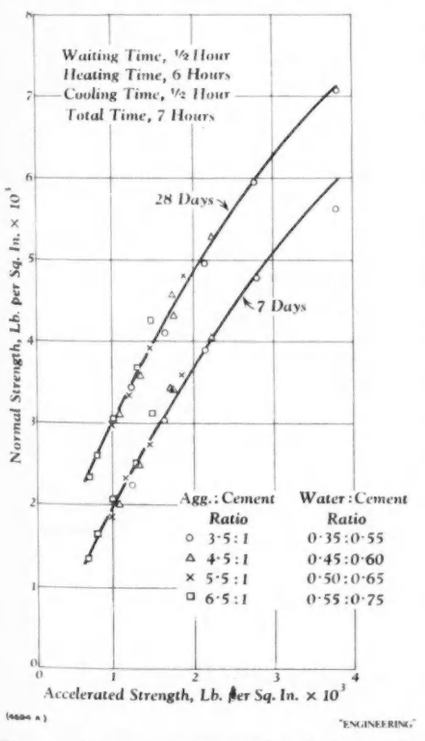


Fig. 1 Close correlation exists between the normal 7 day and 28 day strengths of concrete and the strength measured after a short period—7 hours—of controlled accelerated curing. The data for these curves were established at Queen Mary College, London.

REQUIREMENTS OF TESTS

It was this type of consideration that led the Port of London Authority to the conclusion when its standard concrete specifications were under review that an accelerated-strength test was a real and urgent need, not only in the Authority's own interests but in the interests of sound concrete construction generally. To meet this need the Authority sponsored a programme of research which was carried out at Queen Mary College, London University, between 1953 and 1955, under the supervision of Professor J. W. H. King.[1, 2]

The basic requirements of the accelerated strength tests were:

(1) That they should give a measure of the compressive strength of concrete samples within a few hours of mixing the concrete.

(2) That the results of the tests should be consistent within themselves and bear a consistent relationship to the standard 7 and 28 day tests.

(3) That the apparatus should be sufficiently simple, inexpensive and robust to enable it to be used on site and to be transported from site to site.

(4) That the tests should be applied to a wide range of mixes such as might normally be used in practice.

In the very early thinking the Authority's engineers had considered electrical resistance heating (in which an electric current is passed through the sample) to be a possible approach, but no restriction was placed on the methods to be examined in the research programme and these methods included non-destructive, ultrasonic testing, induction heating and "oven heating." The latter proved to be the most efficient, and most closely fulfilled the requirements.

The technique developed at Queen Mary College consists of heating concrete cubes in their moulds in a temperature-controlled oven at a temperature just below the boiling point of water. Each mould is covered with a metal plate to prevent evaporation and keep the curing conditions uniform for all the specimens. At the end of this accelerated curing, the cubes are allowed to cool and are tested in the usual manner. The accelerated strength so obtained is correlated to the normal 7 and 28 day strengths by means of graphs. Once these graphs are established they may be used for predicting the 7 and 28 day strengths with normal curing from the accelerated strengths.

From the work carried out at Queen Mary College it was apparent that with constant materials very accurate forecasts of 7 and 28 day strengths can be obtained for a wide range of aggregate/cement and water/cement ratios. Fig. 1 shows the relevant curves.

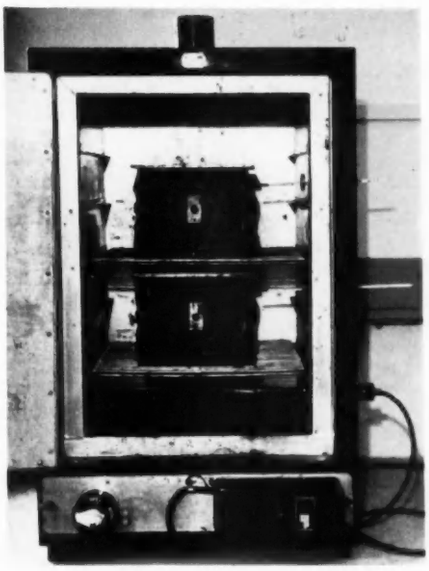


Fig. 2 Controlled accelerated-curing tests for concrete require a suitable oven. For their site laboratory, the P.L.A. use one with a capacity of 3 kW. Two 6 in. moulds are shown with metal covers in place to prevent excessive evaporation.

The scatter on the curves is increased to some extent when the gradings of aggregates and the types of cement are varied. On a construction site the grading of aggregates may well vary from day to day and the properties of the cement used are also likely to vary, even though all the cement might be of one type. It was therefore necessary to investigate the errors introduced into the forecast due to all the variables likely to be experienced on a site.

SITE PROVING

Following the establishment of a suitable technique at Queen Mary College, the Authority set up a site laboratory at their Tilbury Docks, the functions of which were to carry out normal concrete control in connection with a contract for the construction of a passenger and cargo terminal and at the same time to use and develop the new technique.

The site laboratory which was established in November, 1955, contained the following apparatus:—

Oven.—The oven is electrically heated and has a capacity of 3 kW. It can accommodate two 6 in. cubes or four 4 in. cubes at any one time (Fig. 2). The cubes are placed on shelves in the oven to facilitate circulation of air. A circulating fan is not used, as this tends to extract moisture from the cubes. The temperature of the oven atmosphere is controlled by means of a thermostat at 185 deg. F. The maximum variation when conditions are stabilised is less than ± 5 deg. F.

Moulds.—Normal cast-iron moulds both 4 in. and 6 in., with cover plates, are used; the control cubes, tested at 7 and 28 days are the same size as the accelerated cubes.

Testing Machine.—This is a 200 ton, hydraulic, electrically operated machine. It has a proving ring to determine the crushing loads accurately.

Curing Tanks.—Experience has indicated that the control of temperature during the first

Continuing Construction

24 hours has great influence on the strength of concrete and tanks with a controlled temperature of 64 deg. F. are therefore used for curing the control cubes.

HEATING CYCLES

In the experimental stage of the work at Queen Mary College, the heating cycle used for oven curing was as follows:—

Waiting time	.. ..	½ hour.
Heating time	.. ..	6 hours.
Cooling time	.. ..	½ hour.
Total time	.. ..	7 hours.

The waiting time of ½ hour was allowed for sampling, cube making and so on.

As will be appreciated, for site testing, this heating cycle could prove inconvenient, and different heating cycles suitable for site testing have been developed in the Authority's laboratory. Two other methods were considered and are as follows:—

(1) To heat the samples continuously up to a maximum of 24 hours until ½ hour before testing. (2) To leave the samples in their moulds in a constant-temperature curing tank for varying periods of up to 24 hours and then heat them for a suitable period.

Both the methods have been tried out in the site laboratory, Tilbury Docks, but the second method appears more suitable and is recommended for general use. The main reason for this is that, with the first method, the oven has to be left on unattended overnight, which might be undesirable. An additional reason arises from results obtained at Queen Mary College[3] which indicate that the scatter on the 7 and 28 day strength correlation curves is least if an accelerated curing cycle is adopted which gives strengths approximately equal to those obtained with the 6 hour heating cycle. This is important if the properties of the cement are likely to vary and with method (2) the waiting and heating times can be so adjusted that the strength obtained after accelerated curing is very nearly equal to the accelerated strength corresponding to the 6 hour cycle. If the properties of the cement are not likely to vary a great deal almost any convenient heating cycle may be used with reasonable accuracy.

Even when the cement properties may be expected to vary somewhat, the agreement between the strength obtained by the particular accelerated-curing cycle adopted and that which would be obtained by the 6 hour accelerated cycle need not be precise. Heating cycles which give strengths reasonably close to the 6 hour strength, and which are at present in use in the Authority's laboratory are given in Table I. It will be seen that they fit conveniently in a 9 a.m. to 5 p.m. working day.

The first two heating cycles are the most commonly used in the site laboratory, as a day's concreting usually starts in the morning and finishes in the early afternoon.

TEST RESULTS

The tests quoted below have been carried out on samples taken from the concrete made by the contractor in the normal course of the work and this shows that the method can be applied under site conditions. Generally, six cubes are made from each sample. Two of the cubes are subjected to accelerated curing. The other four are cured normally and tested at ages of 7 days (2 cubes) and 28 days (2 cubes). In Figs. 3 and 4, the 7 and 28 day strengths are plotted against the accelerated strengths corresponding to 6 hours and (24 + 4) hours heating cycles respectively, i.e. heating cycles (1) and (2) respectively. The curves drawn are the best curves through the experimental points. The standard deviation of the scatter on each curve is given in Table II.

In assessing the acceptability of the values of standard deviation given in Table II, it should be noted that in the range of samples taken the coarse-aggregate sizes varied from 1½ in. to ⅜ in. and included all-in aggregate, the sand gradings varied from day to day, the properties of consignments of cement varied, and grades of concrete varied, the range of 28 day strength being 2,500 to 7,500 lb. per sq. in. In these circumstances, it is considered that the values of standard deviations are acceptable.

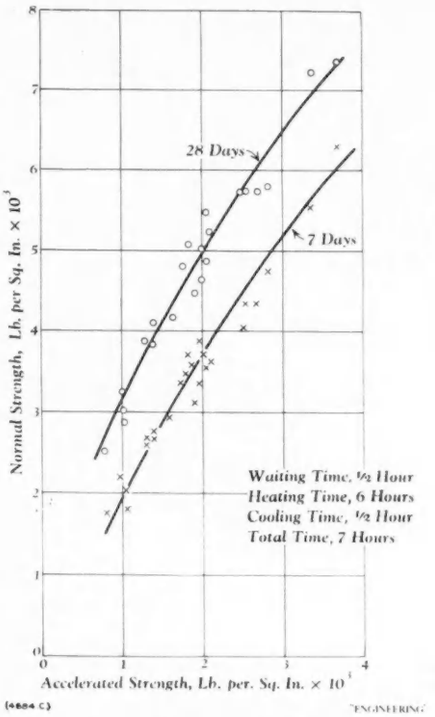


Fig. 3 Curves similar to those established at Queen Mary College but using concrete samples taken out of the works on a contract at Tilbury Dock. These curves demonstrate that the accelerated curing technique can be applied on a works site.

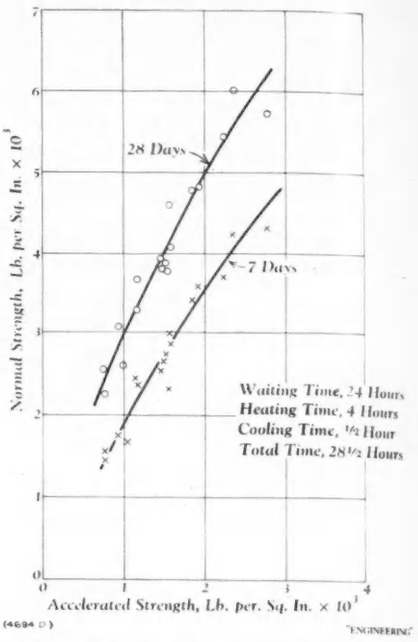


Fig. 4 In the tests summarised in these curves, the accelerated curing cycle was changed from 7 hours to 28½ hours. The consistent relationship with normally cured concrete still obtains.

TABLE I *Heating Cycles Giving Strengths Close to the 6 Hour Cycle Strength*

Heating cycle No.	Sample taken between	Waiting time, hours	Heating time, hours	Cooling time, hours	Total time, hours	Test at
1	9 a.m.–10 a.m. ..	½	6	½	7	4 p.m. to 5 p.m. same day
2	10 a.m.–12 noon ..	24	4	½	28½	2.30 p.m. to 4.30 p.m. next day
3	12 noon–3 p.m. ..	21	4	½	25½	1.30 p.m. to 4.30 p.m. next day
4	3 p.m.–5 p.m. ..	18	4	½	22½	1.30 p.m. to 3.30 p.m. next day

NOTE.—With cycles 2, 3 an 4, the cubes in their moulds are placed in the normal curing tank during the waiting period.

TABLE II *Standard Deviations for the Curves in Figs. 3 and 4*

Heating cycle, hours	Corresponding age, days	Standard deviation, lb. per sq. in.
6	7	236
	28	256
24 + 4	7	216
	28	280

Data for curves corresponding to heating cycles (3) and (4) are now being obtained. From the results obtained so far, it appears that the differences in accelerated strengths corresponding to heating cycles (2), (3) and (4) are small. As an approximation, it may be stated that the strength increase due to an increase in waiting time of 3 hours is of the order of 100 lb. per sq. in. This would mean that small variations in the waiting period would not be important.

EFFECT OF AGGREGATE TYPE

Some tests were carried out on concrete with crushed-granite coarse aggregate. From these it appears that the 7 day strength/accelerated-strength relationships for granite and gravel aggregates are practically the same. The 28 day strength/accelerated-strength relationships for the two aggregates are also practically the same for 28 day strengths below 5,000 lb. per sq. in. For strengths higher than this the curve for granite aggregate rises above that for gravel aggregate, the difference between the 28 day curves increasing with increasing strength. This may well be due to a higher proportion of aggregate failure in the case of gravel aggregate. The crushed granite, being stronger, can withstand higher stresses giving higher 28 day strengths.

The failure of gravel aggregate at higher strengths may also explain the fact that the scatter on the correlation curves (Figs. 3 and 4) tends to increase at higher strengths.

MATURITY LAW

It has been suggested by many workers that the strength maturity relationship for a particular concrete is independent of the curing temperature[4, 5, 6], maturity being defined as the product of age in hours and temperature above a stated datum or the area under the temperature/age curve. This has not been found to be the case when specimens are cured at a high temperature for a relatively short time. Plowman,[7] taking a datum of +11 deg. F., has shown that a maturity law can be applied to concrete cured at all temperatures below 100 deg. F. From the work carried out in the Authority's site laboratory, it has been possible to establish a similar maturity law which will apply to continuous heating cycles of oven curing only. It seems probable that this or a similar law can be applied to steam-cured specimens also. The relationship between strength and maturity given below applies when the concrete is cured continuously at 185 deg. F. The range of temperature over which this law will apply is not yet certain.

To determine the maturity law, results for heating times of 6, 19 and 23 hours (with ½ hour before and after heating) were obtained and graphs of 28 day strength against the accelerated

strength after each of the three heating times were plotted. The accelerated strengths after 6, 19 and 23 hours heating corresponding to five different 28 day strengths were obtained from these graphs and expressed as percentages of the 28 day strengths. These are given in Table III. The maturity corresponding to each heating time was calculated, using 11 deg. F. as the datum, and these are tabulated in Table IV. Graphs of percentage of 28 day strength against the corresponding $\log_{10} \frac{\text{maturity}}{1{,}000}$ are plotted in Fig. 5.

The relationships are seen to be straight lines, and they are, therefore, similar to those obtained by Plowman[7] and are of the form

$$\text{Percentage of 28 day strength} = A + B \log_{10} \frac{\text{maturity}}{1{,}000}.$$

The values of A and B corresponding to different 28 day strengths are found from Fig. 5, tabulated in Table III, and plotted in Fig. 6 against the 28 day strength. The values of A and B follow straight-line laws, but they are not similar to Plowman's results, as he found that the constant A increased, while the constant B decreased, with increasing 28 day strength. It is interesting to note that with accelerated curing, the constants A and B are very nearly equal to one another for all the 28 day strengths in the range 3,800 to 6,500 lb. per sq. in.

The heating cycles in which there are waiting periods of up to 24 hours at room temperature, again follow a different law, and the constants have different values. From *a priori* reasoning, it was thought that in this case Plowman's law should apply for the curing at room temperature, while the maturity law for accelerated curing should apply during the accelerated curing, but it was found that this was not the case. As an example, the accelerated strengths corresponding to a 28 day strength of 5,000 lb. per sq. in. calculated by different laws are given in Table V.

Thus for this type of heating cycle it is not possible to use any of the above laws to relate maturity with strength. It may be possible to determine a different law for this type of heating cycle, but in practice this does not appear to be necessary, as the differences in accelerated strengths for different cycles of this type are small within the variations in cycles likely to be used in practice.

TABLE III

28 day strength, lb. per sq. in.	Percentage of 28 day strength after accelerated curing: Heating time, hours 6	19	23	Constant A	Constant B
3,800	34·2	53·1	54·2	34·1	35·2
4,300	37·2	55·8	58·5	37·2	35·5
5,000	40·0	59·0	63·0	39·8	38·2
5,770	43·3	62·6	68·5	42·6	42·1
6,500	46·1	67·0	74·7	45·5	45·5

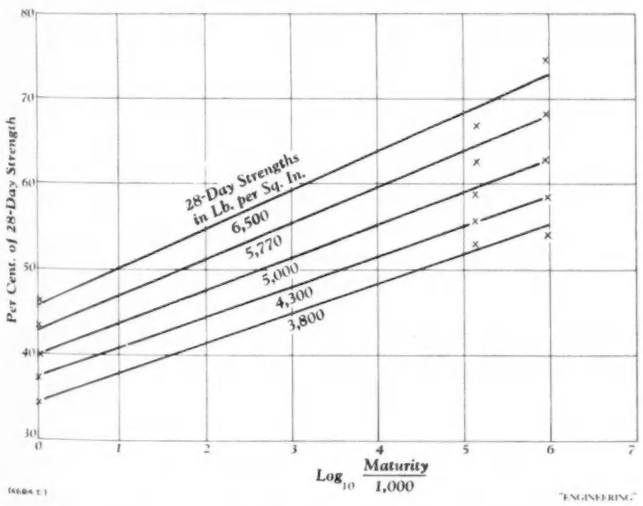
TABLE IV *Maturities*

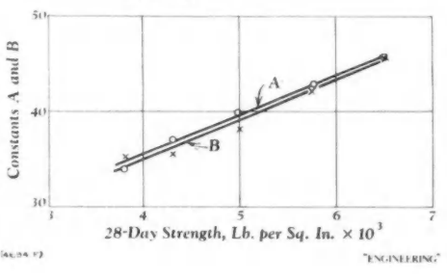
Heating cycle: Waiting time, hours	Heating time, hours	Cooling time, hours	Maturity, deg. F. hours	$\text{Log}_{10} \frac{\text{maturity}}{1{,}000}$
½	6	½	1,005	0·002
½	19	½	3,265	0·514
½	23	½	3,960	0·598

TABLE V

28 day strength, 5,000 lb. per sq. in.
Heating cycle: 24 hours normal curing + 4 hours accelerated curing

Maturity law used for calculating the percentage of 28 day strength after 24 + 4 hours curing	Percentage of 28 day strength
Plowman's law for 24 hours normal curing and authors' law for 4 hours accelerated curing	48·2
Authors' law for whole of the curing	50·1
Plowman's law for whole of the curing	26·7
Actual percentage	41·0





Figs. 5 and 6 Curves illustrating a maturity/strength relationship for concrete cured continuously at 185 deg. F. The relationships shown are similar to Plowman's law for normally cured concrete. A satisfactory maturity/strength relationship was not found for concrete cured normally for 24 hours and then heated.

It is not, in fact, surprising that the maturity laws for normal and accelerated curing are different in the early stages of the curing. The reasons have not been investigated, but are probably connected with the chemistry of cement. It is also not certain whether the changes in the law parameters are a gradual process with increasing temperature of curing, or if there is a critical temperature at which the changes occur. These questions, although interesting, have been considered to be outside the scope of the Authority's immediate concern. They would doubtless be subjects for valuable research of a more fundamental nature.

CONCLUSIONS

It has been shown that the oven-curing technique can be successfully applied to the site testing of concrete at a very early age. The main advantage of accelerated testing has been found to be that it enables trial mixes to be tested within a very short time of their being made, so that if any changes in the ingredients, mix proportions or concrete machinery are made, the results are available before any of the main concreting has commenced. It is also found useful in bringing attention to any significant variation from the acceptable quality of concrete, so that the causes can be ascertained and remedied within a short time.

The heating cycles suitable for site testing are given in Table I. With the use of one or other heating cycle, it is possible to take a sample at any time of the day and test it within a short time.

For accurate correlations it is necessary to control the normal curing temperature for the 7 and 28 day specimens. If oven curing is used on a site without this control, considerable variations may be expected. This is, however, through no weakness of the oven-curing technique. In such cases, it may well be that the predicted normal strengths (from accelerated strengths) will be more realistic than the actual normal strengths, especially if the normal curing temperatures are very low. If the control of normal and oven-curing conditions is good, adequately accurate relationships between accelerated and normal strengths may be expected.

The results quoted all apply to ordinary Portland Cement to B.S. 12.

In May, 1957, the site laboratory was moved to the Authority's Surrey Commercial Docks where another project involving the use of fairly large quantities of concrete is being executed. It may be stated that the correlation curves established at Tilbury site have been found to apply equally well to concrete with different materials and made by a different contractor at Surrey Commercial Docks. It is of interest that, on the Tilbury site, the saving in cement due to modifications of the mix design made possible by the closer control of the concrete quality has far exceeded the cost of setting up the laboratory. From overall considerations of the design and construction of concrete structures it will be apparent that, with greater confidence in the quality of concrete, a more realistic assessment can be made of the factors of safety employed in the design, thus leading to further economies.

Acknowledgment.—The permission of the Authority's Chief Engineer, Mr. G. A. Wilson, M.Eng., M.I.C.E., M.I.Mech.E., to publish this account is gratefully acknowledged, as is his close interest and guidance in the work described.

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CONCRETE TRAIN

A new concrete mixing train which produces concrete as it travels has been commissioned by the London Midland Region of British Railways for main line electrification projects between Euston, Birmingham, Liverpool and Manchester.

The mixer carries its own cement in bulk and sand and gravel are supplied from 50 ton hopper wagons; a water wagon and a generating coach complete the train. All materials are fed into a rotating screw which ensures correct proportioning and completes mixing as the concrete reaches the outlet spout.

Continuing **Construction**

THE CRYSTAL PALACE TELEVISION TOWER

1—*Construction*

The Crystal Palace television tower stands 708 ft. high and the topmost aerials are more than 1,000 ft. above sea level.

On the site of the old Crystal Palace, stands a new B.B.C. television tower, 708 ft. high, designed and erected for the Corporation by British Insulated Callender's Construction Company Limited, 30 Leicester-square, London, W.1; the steelwork was fabricated and hot-dip galvanised by Painter Brothers Limited, Hereford, another member of the B.I.C.C. group. The Crystal Palace, it will be remembered, was originally built in Hyde Park, London, by Joseph Paxton for the Great Exhibition of 1851. It was removed to its final site in 1854 and was gutted by fire some 21 years ago.

The site was chosen by the B.B.C. to permit good reception by the maximum number of television viewers. It is seven miles south of London Bridge and is 360 ft. above sea level. The topmost aerials are thus more than 1,000 ft. above sea level. In addition to the main television transmitting aerials, provision has been made for eight parabolic aerial dishes for receiving vision signals from remote outside broadcasting points.

As a self-supporting tower, the structure as a whole had to be sufficiently rigid to restrict the angle of deflection of the aerials, yet the upper portion had to be slender to comply with the demands of aerial design. Its prominent position emphasised the need for good appearance.

The base of the tower is 120 ft. square. From the ground the lower part of the tower sweeps up in 12 diminishing panels to a height of 429 ft. where the width is 14 ft. 6 in. At this level there is a working platform protected by a steel plate enclosure. Above the platform the aerial-supporting steelwork rises as a series of three parallel-sided sections. Their widths are 9 ft. 6 in., 6 ft. 6 in., and 4 ft. 4 in. They are surmounted by the topmost aerial, which takes the form of a helical tube round a central steel pole.

The tower is built on a foundation of vertical and raking piles which were driven to a depth of 40 ft. and capped with reinforced concrete blocks into which grillages were cast to hold the foundation bolts. The main corner members of the structure were selected to present a low surface to wind forces combined with great strength as struts. For the wide lower part of the tower, the corner members consist of four large angles placed back to back in a cruciform arrangement. For the narrow upper part of the tower the corner members are solid round bars with welded flange connectors. The largest of the bars is 8 in. in diameter. All the connections are bolted together on site.

The total weight of steel which had to be handled in erecting the tower was 450 tons. Individual parts of the upper structure, weighing more than 3 tons each, had to be lifted and placed into position some 500 ft. above ground. During the erection of the panels, temporary stays attached to mass concrete anchorages were used to support the heavy corner members until the bracing connections between them were completed. Two masts, one 230 ft., the other 125 ft. high, were used in conjunction as derricks for the initial stages of steel erection. As work progressed the smaller mast was converted into a floating derrick supported on steel-wire ropes from the corner members of the tower.

By the time the upper portion of the tower came to be constructed, transmissions were taking place from temporary aerials on the main part of the structure. It was therefore arranged to mount a power winch and two luffing derricks on the platform at the 429 ft. level. This permitted steelwork to be taken up the outside of the tower at a predetermined distance from the aerials; at platform level it was necessary to transfer the steelwork from the luffing derrick to the floating derrick above. The topmost aerial pole, dressed with its helical aerial, was lifted in this way up to the 429 ft. level and finally placed in position with the aid of twin summit derricks mounted on the sides of the structure some 670 ft. up, the floating derrick having been dismantled. The Band I aerials which are used for the B.B.C.'s normal television transmission are placed above and below the platform at the 429 ft. level. There is provision between these and the topmost aerial for additional aerials to be fitted when required. For access to the aerials there is a two-man hoist travelling to a landing 398 ft. above the ground. Beyond this point, progress is by a series of ladders within the structure.

The hoist is powered by an electrically-driven winch located at the foot of the tower. It can be controlled from three points, from inside the cage, and from the top and bottom landings. Telephone communication is provided at the same three positions. A point of interest is that the hoist follows up the slope of one of the corner legs of the tower, but remains in a vertical position throughout its run.

Film.—A most attractive colour-sound film of the construction of the tower, entitled "The Phoenix Tower," and running for 42 minutes, has been made by B.I.C.C. Copies of the film in 16 mm. size will shortly be available on loan from the B.I.C.C. Film Library, 21 Bloomsbury-street, London, W.C.1.

2—*Rocket-Excited Vibration Tests*

Shortly after the completion of the Phoenix tower in November, 1957, tests involving the use of reaction rockets were carried out as part of an investigation of the structure's aerodynamic stability.

Within a certain range of wind speeds, depending on the size and shape of the structure, the air flow round an obstruction such as the Crystal Palace tower becomes turbulent and can give rise to a rhythmic lateral movement of the structure, causing it to swing like an inverted pendulum. Should this motion be in phase with the natural frequency of vibration of the structure, or its harmonics, large-scale movements could develop which, if not controlled, would result in collapse of the structure as in the case of the Tacoma Bridge (U.S.A.) which was totally destroyed a few years ago.

The design of a tower or mast to carry television transmitting-aerial systems presents a very special problem since it cannot freely follow the most suitable structural form needed to withstand the wind-forces, weight of aerials, etc., but is bound by limitations of size, shape and deflection in the interests of aerial performance. The problem is particularly difficult with a tower which is unsupported by stay-ropes, and moreover the electrical requirements for Crystal Palace were extremely severe, about 270 ft. of the tower consisting of a series of narrow, parallel-sided columns (the largest only 9 ft. 6 in. wide) on top of a tapering support-structure 440 ft. high. It was found that the tower in this form would have a very low natural frequency of vibration, a property most likely to give rise to destructive aerodynamic resonance, and it was therefore essential to investigate fully the probable behaviour of the tower under critical wind conditions.

Scale models of sections of the tower were tested in wind tunnels to observe and record their movements at various air speeds, the models being held by flexible suspensions whose natural frequency of vibration could be related to the harmonic frequencies of the tower. Tests were

SHIPBUILDING IN FOUR COUNTRIES

British Ships

The most prosperous of our engineering industries and, in the market sense, one of the most soundly based is having a bad attack of jitters. J. Samuel White and Company have three years' work on hand for their shipyard. Yet their chairman, Mr. J. A. Milne, told his company's shareholders that "there is ample evidence to suggest that the sellers' market in shipbuilding may be disappearing." His qualification of this warning—that it might apply especially to companies such as White's "where building berths do not permit the construction of very large vessels, particularly tankers" is more weighty. Yet there is an appalling shortage of modern tramp tonnage and of specialised ships. Mr. Milne is on stronger ground when he says that "the development of a European Free Trade Area will permit opportunities of expanding markets."

Shipbuilders have cultivated the habit of long order books to a point when anything less than three years appears an impending doom. Now they are faced on an average with perhaps four years of work, relatively little of which is likely to be cancelled. Yet many yards have been busy delaying the placing of sub-contracts and orders for materials "just in case" cancellations are received. Any time now the workers will start going slow to make the work on hand last at least through 1961. If they do, the managements will have themselves to blame since practically every announcement that ships are being laid up is followed by some cautionary remark on the part of some shipbuilders.

The facts of the situation are simple enough. The world as a whole needs to use the seas on an increasing scale as a means of transporting materials and goods from source to where they are processed, and from there to their markets. Eventually the harnessing of nuclear sources of energy may reduce this need, perhaps in 15 or 20 years time. Meanwhile a growing proportion of materials and food will have to be taken to industrial centres, and of manufactured goods to agricultural and mining areas. Shipowners are aware of these broad trends and the time cycle in shipbuilding makes it difficult for them to take action on any other basis. Even if there are at present some 100 vessels, aggregating over half a million tons laid up, in Britain, there is a vastly greater tonnage of out-dated ships. This is the other indisputable fact of the situation. British tonnage is not modern enough to compete successfully for world freight. Labour is too expensive to-day and too "choosy" to allow the running of ramshackle slow boats as between the wars. British shipbuilding is in the middle, not at the end, of a wonderful boom.

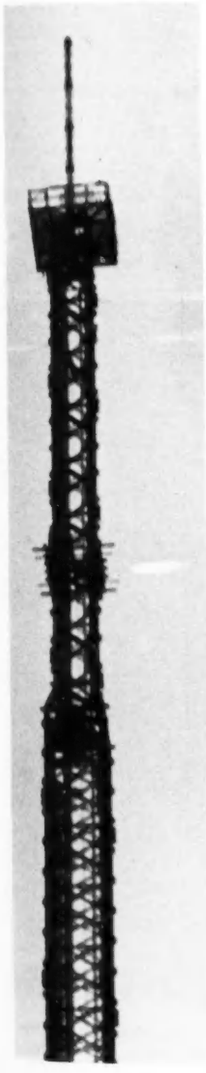
French Ships

Compared with the United Kingdom, the French shipbuilding industry is small. In 1956, for example, French yards launched 301,000 tons, compared with United Kingdom launchings of 1,379,308 tons. France accounts for under 5 per cent. of world launchings while British yards launch over 20 per cent. of the world output of ships. Nevertheless, in terms of activity French shipyards, in common with most of their counterparts abroad, are fully occupied. On July 1, 1957, the French shipbuilding industry had 2·5 million tons in hand or on order, representing a good five years' work.

Despite full employment in French yards, the industry is not without its problems. High costs are one: the 55,000 ton liner now being built by a French yard for the Compagnie Générale Transatlantique, for example, will cost Fr. 25,000 million—about Fr. 7,000 million higher than comparable foreign tenders. The difference is being met by the French Government in the form of a subsidy which has been justified on "prestige" grounds. Under such conditions, French shipbuilders are now mainly dependent on domestic orders. Once the replacement of the French merchant fleet has been completed the shipbuilding industry in France must needs look outwards.

With this in view, French yards are busy expanding their capacity to offer export contracts, and, in an effort to reduce costs, many have adopted modern construction methods which include extensive prefabrication. Widespread conversions have been carried out and are under way in the layout and equipment of shipyards, and fitting-out basins have been extensively developed. This Gallic boldness in expanding in the face of high costs and subsidies may have a strange sound to British ears but it might succeed. If it does, the United Kingdom might have another foreign competitor on its doorstep as technically impressive as the Swedes. In one technological respect the French are already a jump ahead of their British rivals. No British yard can yet take on the construction of tankers of 100,000 tons deadweight. While

also made on typical bolted joints, since much of a structure's ability to withstand vibration is in the damping effect of absorption of energy by friction at the joints. The results of these tests, combined with certain theoretical assumptions, were a useful guide to the probable aerodynamic characteristics of the tower and provided the basis on which to plan a test on the tower structure itself when erected.



The object of this full-scale test was to establish the natural frequency of vibration of the tower, and whether the structure's rate of absorption of energy, i.e., its capacity for damping out vibrations, was adequate to prevent the development of a "runaway" oscillation. It was therefore necessary first of all to excite a controlled oscillation of the tower. A usual method of achieving this is to pull over the head of the structure by means of ropes, but this was not suitable at Crystal Palace because ropes could not be properly positioned at ground level on the small site, and also because the long and heavy ropes required would themselves have a large damping effect which would mask the tower's own resistance. To avoid any external damping of this kind, the applied forces would have to be initiated on the tower itself.

The best method was to use the reaction from firing rockets firmly fixed to the structure. Rockets provided and controlled by the Royal Aircraft Establishment, Farnborough, were mounted on a frame fixed to the tower at 630 ft. above ground level and arranged to fire horizontally from one face of the tower, each rocket having an electric detonator connected to a central firing-point on the ground. A mobile laboratory operated by the National Physical Laboratory was set up close to the firing-point to record the movements of the tower as measured by accelerometers fixed high on the structure.

On November 20, after a preliminary test firing, ten rockets were placed in position ready to be detonated successively in phase with the frequency of the tower movement as traced in the mobile laboratory, so that the oscillation would increase as each rocket was fired. This procedure would give maximum control of the operation since, if the movement became excessive, the firing of further rockets could be stopped or the oscillation could be damped by firing a rocket out of phase with the frequency of vibration.

Unfortunately, during the test, one rocket misfired and the next was detonated out of phase, causing a reduction instead of an increase of oscillation and limiting the tower movement to about 4 in. each side of the vertical. This was not enough to give all the information required. The results obtained had shown, however, that a much larger initial force could be safely applied and it was therefore decided to make a further test involving the detonation of six rockets simultaneously. This was carried out on the following day, and the total thrust of about 2·14 tons from the six rockets against the 450 ton structure produced an oscillation of 8 in. each side of the vertical.

The instrument recordings made in the mobile laboratory are now being analysed and it is expected that the results of these tests, believed to be the first of this kind on a high tower, will be of value not only to the study of the Crystal Palace tower but also to the future design of similar structures.

(Left) To establish the natural frequency of vibration of the tower and its capacity for damping out vibrations, rockets were fired from a frame mounted on the tower 630 ft. above ground level. Here, a single rocket is shown firing. In the final test, six rockets were fired simultaneously.

(Right) Electrical bridging tests being made on the aerials. In the background is the two-man inspection hoist which gives access to the aerials.

Continuing **Construction**

admittedly no tanker of this size has yet been ordered from a European yard, the trend of orders is towards the " super-tanker " and it is claimed that tankers of up to 130,000 tons d.w. could be built at St. Nazaire; already the yards there have gained an order for two 73,000 d.w. tankers from Tidewater Oil in the United States.

German Ships

Plans for building passenger ships in German shipyards have not materialised since the war. The main reason is that a big building programme could only be carried out with State help in the form of subsidies. To build up a passenger fleet Germany has been buying steadily from abroad. One recent purchase is the 27,000 ton Canadian Pacific liner bought for the New York-Hamburg route by the newly formed Hamburg-Atlantic Line. The former French 30,000 ton troop-carrier Pasteur has been bought by North German Lloyd. Other secondhand buys have been the Berlin of 18,000 tons, the Seven Seas of 12,500 tons and the Ariadne of 8,000 tons.

Meanwhile although no passenger ships for German lines are going down the slips the Federal Republic's shipyards are breaking production records. In 1957 they turned out 323 ships with a total tonnage of 1·1 million tons. This is 90,000 tons more than 1956 output and leaves unfilled orders for a total of 5½ million tons. This pile of orders estimated to be worth 8,000 million D Marks (about £666 million) will keep the West German yards busy until 1963. About two-thirds of the 1957 output was built for foreign customers. The main emphasis was on 15,000 to 25,000 ton bulk carriers, not on super-tankers as it had been earlier. The Deutsche Werft, Germany's leading shipbuilding firm, built 15 ships last year and is now building ten ore carriers for a Los Angeles firm. The state-owned Howaldtswerke has the longest list of orders to fill, partly as the result of last year's 2½ month strike at Kiel. The boom is being felt from top to bottom of the industry. Even the small yards turning out coastal vessels, claim that they have enough work for the next two and a half years.

American Ships

Mr. Walter L. Green, the chairman of the board of the American Bureau of Shipping, is reasonably optimistic about the future of the shipbuilding industry despite the recent fall in new orders. Discussing the world outlook for the shipbuilding industry he pointed out at the annual meeting recently that 1957 had been a period of unusual expansion. The trend towards large oil tankers, large bulk carriers of cargo and specialised tonnage was common in the major shipbuilding yards of the world. The industry now has a back-log of over 30 million gross tons and some yards are still booked for four or five years ahead.

Major shipyards have been engaged in making provision for the new, large type of vessel. The installation of new building ways, the expansion of existing berths, the construction of big graving docks and the modernisation of shops and equipment is going forward into 1958. The expansion is particularly marked in Holland, Sweden, Great Britain, Japan and the United States. Last year saw a significant expansion in Norwegian capacity and this year there is to be an expansion in Denmark and a new shipyard in Greece. In America the Ashtabulla shipyard in Ohio on the Great Lakes is to be reactivated. Mr. Green considers that there has been a significant contraction in orders received in Germany, Japan and Sweden, and that there are signs of price cutting to get business. Nevertheless, he views the long-term expansion of shipyard capacity with optimism and concludes that " no doubt in years ahead (it will) prove to have been a wise one."

FASTER WORK WITH CONCRETE TUNNEL LININGS

Concrete rings, made up from segments as shown in the illustration opposite, with dry joints and without grouting, are being used to line railway tunnels. The main-line tunnels now being driven through clay hills near Potters Bar, 12 miles north of London, are the first to be lined in this speedy and economical way. The rings have an outside diameter of 31 ft. 0 in. and a width of 18 in. Progress in driving the tunnel and lining is averaging 4 ft. 6 in. (3 rings) in each 8-hour shift. Bearing in mind a number of similarities, the technique now being tried and proved at Potters Bar suggests a possible method for lining the Channel Tunnel.

The work at Potters Bar is part of the East Coast main line widening scheme of Eastern Region, British Railways, which will enable a bottleneck 2½ miles long to be eliminated by the addition of two extra tracks linking up with the four tracks already operating north and south of the work. Widening the section has involved major earthworks in existing cuttings and three new double-line tunnels, 384 yd., 232 yd. and 1,214 yd. in length. The tunnels have an internal bore of 26 ft. 6 in. to accommodate the overhead equipment required for future electrification at 1,500 volts. Also involved were the reconstruction of Potters Bar Station (completed in 1955); the rebuilding of Hadley Wood Station (now in progress) and the construction of an extra span to the adjacent road bridge; provision of a new 42 in. aqueduct to replace an existing structure; and the abolition of a signalbox (Greenwood) and the installation of colour-light signalling and track circuit throughout the section.* The design of the scheme as a whole has been undertaken by the Chief Civil Engineer of the Region at Kings Cross, with the assistance of Sir William Halcrow and Partners as consultants, particularly in respect of the tunnelling operations. The design of tunnel, including the lining technique, is attributed to Mr. H. D. Morgan, M.I.C.E., senior partner of the consultants, who are also advising the current sponsors of the Channel Tunnel.

The tunnelling equipment being used comprises a circular shield, 31 ft. in diameter, a conveyor belt system for getting the spoil (hard brown clay with traces of blue) back from the working face, and an erecting frame for the concrete lining. The equipment is illustrated below; the photograph on the left is looking forward to the erecting frame and immediately beyond it to the shield and working face; that on the right, taken from the same point, looks backwards past the spoil-conveying system down the completed tunnel. The 24 in. gauge light railway is part of a 7½ mile system which has been built by the contractor, Charles Brand and Son Limited, to assist with work throughout the section.

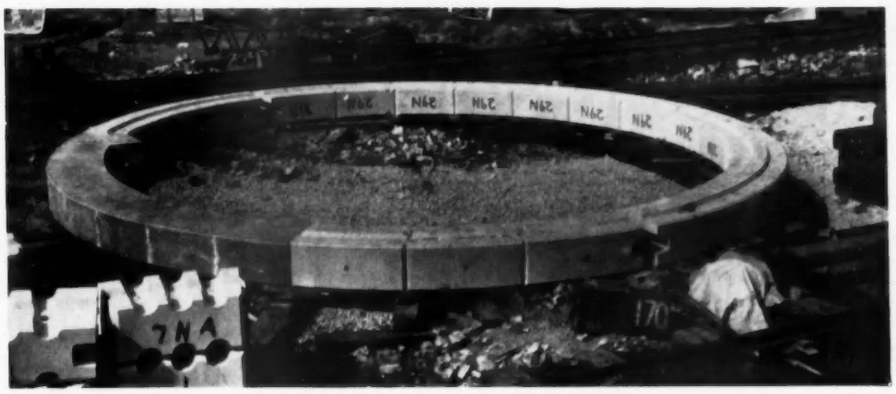
For each of the three tunnels both portals were built in trench prior to the tunnelling operation. Where the overburden is shallow, just behind the portals, the tunnels have been lined with conventional cast iron segments bolted together and pressure grouted with cement. Abutments were prepared outside the portals from which the shield could be initially driven forward. The tunnel linings were first built outside the portals as far as the abutments and the first spoil to be excavated was taken out by buckets craned through the crown of the tunnel from which segments had been removed.

When a sufficient length—say 30 ft.—of the tunnel had been driven and lined with cast iron the lining was changed to the concrete rings. Each ring consists of a reinforced invert weigh-

* Previous articles on these schemes have been published in ENGINEERING as follows: " Railway Widening and Reconstruction at Potters Bar," vol. 173 page 407 (1952); " Reconstruction of Potters Bar Railway Station," vol. 180 page 830 (1955); " Railway Modernisation," page 540 (October 25) and page 599 (November 8) vol. 184 (1957).

Behind the working face in the new double-track tunnels being driven for the Eastern Region main line at Potters Bar. The erecting frame for the concrete lining is coupled to the back of the shield.

A Technique that will be adopted for the Channel Tunnel?



A trial ring of lining segments laid out for checking. The rings are built into the tunnel with dry joints and without any grouting between the lining and the clay bore. The cost with this form of construction is less than 40 per cent. of that had cast-iron segments been used.

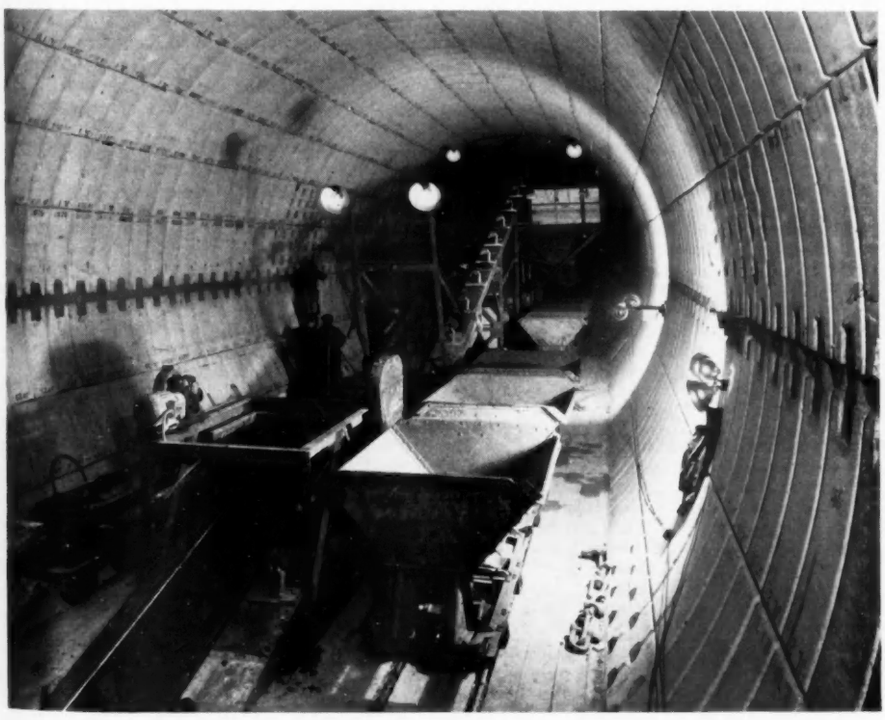
ing about 4½ tons with three interlocking segments on either side forming the lower half of the ring. The upper half of the ring comprises 13 segments, six to each side and these are held in position by the erecting frame until the crown segment is put into position by a lifting platform fitted to the rear of the shield. The guides for the platform are composite with the back stiffening of the shield and are to be seen in the left-hand illustration below. Also to be seen in this photograph are the components of the erecting frame: on the left-hand side, the telescopic arm is extended to hold six newly-erected segments in position; on the right the last of the segments is being put on to the frame before erection. The crown segment is then raised into position.

To complete erection, jacks are put between the upper and lower halves of the ring and the two halves forces apart and against the excavated wall of the bore. Dry concrete is rammed around the jacks, which are ultimately removed and the jacking pockets filled with more concrete. These filled pockets are clearly to be seen in both the illustration looking back down the completed tunnel and in that of the trial ring above.

The segments, apart from the invert, are un-reinforced; they interlock with each other and each ring is interlocked with the next. This is achieved by chases and spigots on the faces of adjacent segments. A metallurgical super-sulphated acid-resisting cement has been used for the concrete to obtain protection against attack by sulphates in the clay and by engine fumes. For manufacturing the segments, a temporary factory has been established on adjacent land connected to the working sites by the small-gauge railway. Steel moulds have been used for all units and a 28-day strength of around 7,000 lb. per sq. in. has been obtained for the concrete. The cost of tunnels lined in this way, by mechanically handled concrete segments, is said to be less than 40 per cent. of that for lining them throughout with conventional cast iron.

Nearby, at Ponsbourne, is the last double-track tunnel of importance to be constructed in clay, completed just before the first world war. Several miles of London Transport tube tunnel have, of course, been driven since that date, but they are single track and for a very much smaller stock; some were lined with cast iron, the remainder with reinforced-concrete segments of very similar pattern to the conventional cast-iron segments. Ponsbourne, however, was lined with seven rings of brickwork—a method that can hardly even have been considered for the new tunnels. The old tunnels at Potters Bar, much older, are of similar brick construction and a prime concern during the work in progress has been to avoid damage to the old tunnels.

The shield being used for driving the tunnels is about 150 tons in weight and has four galleries; it is fitted with 25 hydraulic rams which drive it forward about 18 in. at a time, iron kentledge being disposed in the invert to correct rolling. Pneumatic spades are being used to cut into the working face; the spoil from the upper galleries is shovelled into chutes leading to the conveyor belt which carries it back for loading away by skip trains. The spoil from the invert is thrown straight on to the conveyor.



The completed tunnel showing the conveyor system used for taking the spoil back from the working face. The jacking pockets, filled with dry concrete, are clearly seen along the wall of the tunnel.

The conveyor system was designed and built for the contractors by the Fraser and Chalmers Engineering Works of the General Electric Company. The equipment is carried on a steel framework, 116 ft. long, 17 ft. wide and 23 ft. 6 in. high. Mounted on it are two 36 in. conveyor belts, the first of which is retractable in order to allow the invert block to be inserted. A platform and track for a 3 ton travelling crane are provided over the retractable conveyor. Rail tracks of 24 in. gauge are laid down the whole length of both sides of the framework, and an electrically-operated traverser is provided under the second (elevating) conveyor for moving the wagons from one side to the other. The spoil-loading hopper is at the discharge end of the elevating conveyor.

A hydraulic accumulator and pumps for operating the rams are mounted at the rear of the framework, which also carries all the necessary electric motors and switchgear. Skids underneath the framework rest on greased concrete ledges, which are integral with the invert blocks. The whole assembly is coupled to the shield and advances with it.

The advantage of the conveyor system is that it assures the continuous removal of the spoil from the working face, except during the comparatively short time required to drop the invert blocks into place. The expense of the plant is justified by the speed and continuity of the operation. Though at first glance the 36 in. conveyor belts provided would appear to be unnecessarily large for the removal of no more than 15 cub. yd. of spoil per hour, with the cutting-shield method of excavation the discharge of clay from the face is liable to be irregular, with occasional high peak loads. The wide belts provided clear it with minimum spillage and consequently without the expenditure of time and labour in clearing out the bottom of the excavation.

From the foregoing it will be seen that a construction routine has been devised which makes use of a high proportion of mechanical equipment for handling spoil and the tunnel linings. The rate of advance, remembering the tunnel diameter is 31 ft., is very high for a relatively small labour force. Earlier it was suggested that the method might one day be used for the Channel Tunnel; apart from the greater magnitude of the Tunnel, there are, it is true, many differences from the conditions at Potters Bar. The Tunnel will be through chalk, not clay, and it may not be possible to trim the former so closely that grouting can be dispensed with, but dry joints will still be practicable between the segments and the rings. The twin bores below the Channel may well be only 16 ft. 6 in. or so in internal diameter (allowing for third- or fourth-rail traction) but this would make handling of the lining rings easier. The Channel Tunnel —economic proposition that it is—may not be so far off, and when it is built some sort of construction technique very similar to that now being used at Potters Bar could well be adopted.

Book Reviews

PHYSICS IS NOT ENOUGH

Three Steps to Victory. By SIR ROBERT WATSON-WATT. *Odhams Press Limited, Long Acre, London, W.C.2.* (30*s*.)

The pure scientist who has achieved some scientific eminence is usually content to bequeath to the world, as a monument to his life, the scientific papers in which his researches are enshrined. The applied scientist or engineer may be able to say, as with Wren and St. Paul's Cathedral, "*Si monumentum requiris, circumspice*," and point to evidence of their achievement more concrete than marks on paper. But scientific papers and engineering constructions are the end of a creative process; they do not show us how the creative process began or how it was motivated. A biographer, searching for clues among the unpublished papers and letters of his subject, may sometimes tell a little more about the man behind the façade presented to the scientific world. But nothing can be so revealing—and not always in the way the author intended—as an autobiography.

Autobiographies of scientists, as compared with those of politicians and diplomats, are rare—all too rare. As technology increasingly dominates our social, political and economic lives, it becomes increasingly important to know what kind of man it is whose technological visions, whose judgments and values shape our future. Are these men the "mere technologists," the "faceless technicians" that some would have us believe?

Increasingly, the rate of technological development is determined not solely by the initiative of private entrepreneurs but also by the political and economic decisions of government authorities. The capital resources of private investors are no longer adequate to meet the capital demands of modern technology and the limited supply of public funds must be shared among competing demands. "Zeta," for example, is a great technological achievement; it also holds the promise of reducing this country's dependence on imported oil and therefore has political implications of significance. But what man can assess with accuracy both the technological and the political or social promise of such an achievement? It is on such assessments that delicate judgments of priority must be made by those who govern us. For such judgments to be possible, however, a new kind of co-operation must be forged between the scientist, engineer and industrialist on the one hand and the politician, economist and administrator on the other. How can the mutual confidence on which such co-operation depends be established? How can each side, scientific and humanistic, understand and appreciate the disparate visions of the other and reach a happy compromise?

The autobiography of Sir Robert Watson-Watt throws some light on these matters. He has a story of great success to tell. On him fell the task of convincing those in authority that the uncertain flickering on the first crude radar screens could, given sufficient money and effort, protect this country against the impending attack. On him fell the task of deciding to what ends our limited scientific resources should be applied. Would the attacker come by night or by day? Through the air or under the water? These and many other judgments had to be made, in time and in the right order, and on the scantiest of evidence. But not only had he to make the right judgments; he had also to persuade men with only the vaguest awareness of scientific potentialities and convince them of the correctness of his decisions.

Some of Watson-Watt's scientific collaborators, while readily acknowledging the importance of his early scientific work, have underrated that of his work at the Air Ministry from 1938 onwards, at first as Director of Communications Development. To them he seemed to have sacrificed the excitement but discomfort of a true experimental scientist working at the bench for the dull comforts of the armchair of an administrator or "mere salesman." But if ever the scientists (and all of us) needed a salesman for their ingenious devices it was at that time; it is difficult to imagine how any scientist of lesser calibre than Watson-Watt would have had the necessary powers of persuasion. This obstinate scientific visionary with the "gift of the gab," with an uncanny knack of avoiding all attempts to limit his freedom of action (and of speech), and an ability to thrust aside or circumvent all obstructions, human or material, finally brought radar from the uncertain flickerings of its infancy to full maturity as a penetrating offensive weapon which first sapped and then shattered the morale of Nazi Germany.

Sir Robert's autobiography, however, falls short of the great book it might have been. Unfortunately, after the war was won, Watson-Watt was hurt by what he felt to be official minimising of radar's part in the victory. Whatever may be the rights and wrongs of the controversy that followed, there is no doubt about the hurt that Watson-Watt suffered. The memory of the wound has led him to continue to clamour in this book for recognition as "Father of Radar," a claim which, without his clamour, might have been the more readily conceded by all but the few other claimants. So the straightforward account of his battle for radar, which we hoped for, is distorted. This is a pity, but at the same time it reminds us again that even physicists are human.

The book has other defects. The style is rambling; the sentences are overloaded with commas and parenthetic comments. The author has written for those familiar with the profusion of alphabetical code names used in war-time radar—CH, AI, GCE, GL, GCA—for those who can visualise what is meant by going from TRE to ADRDE, or from MIT to ACE; an index of such abbreviations would be helpful. There is no simple description adequate for the layman of what tasks the many ingenious devices were performing; an explanatory technical appendix is needed. The temporal sequence of events is constantly blurred, here by a glimpse into the future, there by a flash-back into the past; a chronological summary would help the reader to keep in step with the author. And so a book which so clearly reveals the mental attitude of a scientist to his work and to his colleagues may go unread by those who have most to learn from it.

In spite of these defects, the moral of Watson-Watt's autobiography is clear. His major thesis is that "engineering has three parts: (1) the directing of the forces of nature, for (2) the use and convenience of man through (3) the operation of intellectual and emotional processes which are essential to measuring the need and directing the forces." He pays generous tribute to the moral courage and statesmanship of the Treasury (rare indeed!), to the senior officers of the R.A.F. and to the Ministers he served. In the atmosphere of confidence these men created, "the Air Marshal took advice from the junior scientific officer on how to make war, and the laboratory assistant was told by the Admiral why physics has sometimes given way to psychology in the planning and conduct of operations." By contrast, in Nazi Germany the military *élite's* distrust of academic and intellectual distinction led to a situation in which the research scientist was carefully isolated from the industrial manufacturer and from the operational user of his inventions.

The technical development of radar through its main phases is an exciting story: from the germ of an idea in the mind of a meteorologist tracking thunderstorms, through its tentative use as a defensive warning system, to its success in directing the famous few to their multiple targets in the Battle of Britain, and beyond that to a bewildering diversity of ingenious offensive instruments. This story has already been told by others. But it is not complete; for the whole story must tell also of a great co-operation between boffin and layman, serviceman and civilian, engineer and administrator. It was the difference in the co-operation achieved, rather than in the technical ingenuity displayed, that won for Britain the decisive margin of radar superiority over Germany. In Watson-Watt's own words: "physics is not enough."

THE PIED PIPERS OF BIRMINGHAM *By Sir Robert Watson-Watt*

The following extract from "Three Steps to Victory" forms chapter 50 *in the book. It gives an account of the development of the magnetron, a device which was to become the heart of the radar transmitter. The chapter appears just over halfway through the book, between others headed "Wanted! —Watts on Watts!" and "The Man with the Black Box."*

The Birmingham University passengers from our Shanghai Express used the return portions of their tickets by the end of September, 1939. They went home to apply their wide knowledge of physics *in vacuo*, now set in a frame of radar practice and radar needs, to research, under Admiralty auspices, on the generation of centimetric waves. They had a generous charter of freedom, it merely said "Give us many watts on few centimetres." Oliphant, Sayers and Dawton undertook to explore the possibilities of the only existing "high-power" centimetric-wave generator, the Klystron—and "high-power" (which meant million-watt peaks in our existing radar pulses), meant a few tens of watts when we talked of existing klystrons. Moon and Nimmo were on a better wicket in exploring the klystron as an amplifier, mixer or detector. Titterton was to make the best use he could, on 50 centimetres, of the micro-pup triode which we had used widely on 150 centimetres.

Randall and Boot were to see what they could do with modified Barkhausen tubes, and to consider the possibilities offered by plasma oscillations in mercury-vapour discharge tubes. They had drawn two poor starters; plasma was very discouraging; Barkhausen could apparently be made to work only when Barkhausen had been made to work as an oscillator with which to test other Barkhausens—and it hadn't! So they decided to make up a small magnetron as a test oscillator for the Barkhausen experiments. As they waited for the electromagnet they needed, they thought and talked a lot about magnetrons, not as test oscillators of quite low power, but as possible high-power generators.

They saw clearly the limitation of the klystron. It was the electronic equivalent of a toy "musical" instrument of my childhood, which had two very small tin saucers face to face, soldered together round their rims, each with a small hole pierced through its centre. Blowing

through these two holes (which faced one another so that one could look through both at once) made the air in the resonant cavity thus formed vibrate at the natural frequency of the cavity. The harder one blew, the louder the note, but the pitch was almost unchanging. The rhumbatron was just such a resonant cavity, the harder you blew a stream of electrons through the two central holes, the " louder " the electrical " note " of fixed pitch, i.e. the more intense the the electromagnetic oscillations, of substantially constant frequency, which were produced. In both cases the jet blown through the holes was modulated by these oscillations in the resonant cavity. In both cases the main difficulty was to blow hard enough to get a really powerful oscillation in the jet. Randall and Boot saw little hope of success, however hard might they huff and they puff to blow the electrons down. Clearly the trouble was not with the cavity, but with the way it was used in the klystron.

The older magnetrons were more sophisticated in principle—but even less effective in practice. They blew a little whirlwind of electrons round and round in a space, of circular cross-section, inside a cylinder of metal, the cylinder being either complete, in the earliest and least useful, or divided by axial cuts into two, four or more separate segments. The whirlwind was modulated, at a substantially constant frequency, in the same general way as was the rough but outside-in acoustic counterpart of the magnetron, the already too familiar air-raid siren, in which a powerful straight blast of air blew against a series of air cavities presented to it by a rotating slotted drum. There was almost daily evidence that very powerful sound waves indeed could be generated in the air jet in this way; there was reason to suppose that very powerful electromagnetic waves could be generated in the magnetron, especially if a moderately large number of properly shaped resonant cavities were nicely spaced around as the wings of the electron whirlwind's circular stage.

This was not how Randall and Boot thought, but it is my kind of infant-primer guess at the nature of their thoughts. Randall was not merely (forgive, O Cambridge, this pejorative adverb) a Cambridge physicist, he had also been a Wembley physicist, having worked on thermionic valves in the Research Laboratories of the General Electric Company. One part of his education showed him what one could reasonably hope to do, the other what one could not reasonably hope to do—but also the kind of way in which the reasonable hopes could be fulfilled.

Jets of thought played over resonant cavities in the mind, and then one day, Randall and Boot sat down quietly after luncheon—and rose for laboratory tea, with a few sheets of paper in their hands. The work of a single afternoon had gathered into a single note, which I like to call The Magnetron Memorandum, the harvest of many sowings, from many sources, in the fertile ground of two acute minds. The Magnetron Memorandum was a communal manifesto for the Centimetric Revolution in Radar, and it was also, like an earlier Memorandum in radar, a detailed specification from which one skilled in the art could construct a successful, useful and powerful embodiment of an elegant invention. And, for both Memoranda, what better plan than to let the authors crystallise their own ideas into hardware and into a system?

Their experience of " old-fashioned " radar at Ventnor CH was not unimportant in the invention. The pulse-method of working which had been urged in the Radar Memorandum of February, 1935, was, for the reasons indicated in that Memorandum, peculiarly suited to the subject matter of the Magnetron Memorandum of November, 1939; it spared the only fragile element in the magnetron, its hot-wire cathode, from the continuous electrical loading which would destroy the coating of copiously electron-emitting material which we had found invaluable to our " over-run " transmitting valves, and which Randall and Boot were thus encouraged to use.

Some three months of machining, of manufacture of the very considerable ancillary equipment, big electromagnets, high-tension rectifiers and so on, and bench assembly, followed. Much of the heavy work of making the essential auxiliaries was done in the Laboratory, to avoid the long delays threatened on outside purchase; the high-tension rectifier, for example, was so built, and like the magnetron itself was continuously evacuated by laboratory vacuum pumps.

On February 21, 1940, the new device was successfully operated. The results were spectacular. A hand brought near the output lead became uncomfortably hot, this was *very* high-frequency " therapy " indeed. From the end of the output lead, as the power was gradually increased, a blue-violet electric arc sizzled outwards into the surrounding air. The heating current had to be switched off from the filament because the electron bombardment overheated it—many later magnetrons ran without filament currents after starting up. A sudden drop in output power was traced to the melting of the output loop by the unprecedented centimetric-frequency power which it was carrying.

A thin stream of lab-boys flowed between the laboratory and a local garage, bearing a succession of 6-volt lighting bulbs of higher and higher power rating, as each in turn was burnt out by the centimetric power. This *embarras de richesse*, as is witnessed by the laboratory notebooks, led to attempts, fortunately wholly unfruitful, to show that these great output powers were on metric and not on centimetric powers. When neon floodlighting tubes, 4 ft. long by 1½ in. diameter, blazed in full glory, it was clear that the average output power was not around the few watts of the past, not the previous world record of a few tens of watts, but very nearly half a kilowatt. Next day a frequency-measuring equipment was " lashed up," and showed that the frequency on which this flood of power was flowing was 9·8 centimetres—instead of the 10·0 centimetres at which this masterly arrow, shot into the electronic unknown, had been aimed. It may have been, technically, a near miss; all things considered, it was a super-gold, and on the first draw. Nor was it to be dismissed as having even the merest suggestion of a " fluke " in it; the reasons why the earlier magnetrons had been bad were clear in the minds of Randall and Boot; one big reason was that they had, *inter alia*, wasted much of their very limited sweetness on the desert air by resistive and radiative losses.

Within some three months, during which a most cordial and productive co-operation with Wembley was set up, the redesigned and sealed-off resonant-cavity magnetron, looking very much as it does to-day, was delivering 50 kW of peak power at a wavelength of 9·1 centimetres. It was almost more difficult to design means for measuring these powers than it had been to design for their production!

On July 27, 1940, substantial—and substantial on the post-Memorandum rather than on the pre-Memorandum scale—power was delivered on 5 centimetres; very soon after came useful power on 1·9 centimetres. By March, 1941, a report on the existing state of the work showed still further strides in performance, including an astounding efficiency, reaching 59 per cent. in one case, in the conversion of pulsed direct-current input power to centimetric output power.

In May, 1941, the parts for a 10-centimetre magnetron designed to deliver peak powers of 3 million watts were produced. The University Laboratory now became, in part, a factory—with an average age under 19 in its " operatives." Twenty magnetrons a week was a rate frequently attained; between 1941 and 1943 over a thousand magnetrons were produced in this academic grove. The further story of university and industrial mutual aid, and of large industrial manufacture to almost unmodified university design, belongs elsewhere. The Pied Pipers of Birmingham, who played on the electronic members of a family of musical instruments, whose country cousin is the Penny Whistle and whose Chelsea branch is the Recorder, stand high among those who deserve well of their country.

On the Shelf

By Frank H. Smith

A point I have intended to raise for some time is the habit some authors have of saying " A figure is given for " and then carry on to give some quite definite number for the production of paper-backs in Patagonia for the years 1888-9. They then proceed to give more figures " it is therefore calculated that " and leave you breathless with their capacity for producing statistics. The point is they rarely give their authority or, if they do and the reader takes the trouble to look it up, he will find that the previous quoter has also said " It has been calculated." Note the delightful impersonality of it all. One of these days when I am listening to such a lecturer, I shall not wait until question time at the end but I shall leap to my feet and cry " Where the devil do you get those figures?" and I'll bet the speaker will be so nonplussed that he'll eat the rest of his paper lest it be taken down and used in evidence. As it is, most of them get away with it and thus maintain a reputation for being shrewd and authoritative. The danger is, of course, that the figure (which may have been pulled out of a hat by the originator) gradually becomes accepted, and, as future speakers have a habit of adding 10 per cent. for a year's increase on whatever it is they're talking on, when a really detailed census comes to be taken it is found that the actual figure bears no relation to the calculated one.

Here's confusion. *Discovery* is the official publication of the University of Melbourne and, as it has only reached No. 2, I feel that the editors should have exercised their brains just a little more and used a title that was not already in existence. A beautifully produced and printed journal, free from advertisement, attractively covered and full of interesting material, becomes, as it were, ashes in my mouth.

There are a few books in science which, like standard dictionaries, are better known by their authors than by their titles. I have not hitherto come across " Kolthoff " since Chemistry has never been my subject, but I see that Interscience Publishers announce *Volumetric Analysis* as the complete " Kolthoff " in three volumes. Volume I (Theoretical Fundamentals) is priced at 60*s.*, Volume II (Titration Methods) at 66*s.* and Volume III (Titration Methods) at 115*s.*

Bailey Brothers and Swinfen, Hyde House, West Central-street, London, W.C.1, have issued a second supplement to their catalogue of technical, scientific, etc., dictionaries.

My name being what it is, I am particularly delighted to report the birth of a new house journal called *The Forge*, issued by the Brockhouse Group of Companies. They have called it *The Forge* because the group is largely concerned with metal working in its many aspects and successive numbers of the journal will describe these activities.

Who wants to make a telescope? It's indispensable if you want to follow any forthcoming " sputnikery," and Interscience Publishers have published just the thing. *How to Make a Telescope*, at 3.50 dols., has been translated from the French of Jean Texereau by Allen Strickler. By the way, 3.50 dols. is the price of the book and not of the finished telescope. From the chapter headings it looks as though you do the lot yourself including making the mirrors, so, unless you are prepared to take your jacket off and really get down to it, this book will not interest you a lot.

Even the remotest sort of secondhand catalogue is liable to have its little surprise tucked away in a corner. For instance, *Fra Lynge's Reoler* Nr. 218—the Botanik-Fysik-Kemi-Matematik catalogue of Herm. H. J. Lynge and Son of Løvstraede 8-10, Copenhagen (all prices in Danish crowns) contains item 2127: ENGINEERING, Vols. 57-59, 61-66 Ldn., 1894-98, 4to. hf. clth.: 75·00. I make this about £4, which is not at all bad.

Continuing **Book Reviews**

NAVAL JANE'S 60TH BIRTHDAY

Jane's Fighting Ships, 1957-58. Compiled and edited by RAYMOND V. B. BLACKMAN. *Sampson Low, Marston and Company Limited, 25 Gilbert-street, Oxford-street, London, W.1.* (105*s.*)

To all who are concerned with warships, or even merely interested in them, the appearance of the successive issues of *Jane's Fighting Ships* has been an event of the year ever since its first publication in 1897, but a special welcome must be accorded to the issue for 1957-58. Not only is this the 60th volume of a series which has no rival or even serious competitor in the world, but the new *Jane* comes out in a format much more convenient to handle than its predecessors, and with a wealth of information without previous parallel. The longer dimension of the page is now vertical instead of horizontal, which greatly facilitates rapid reference and also shelving; more than 800 new illustrations have been introduced; and the amount of information now given in the tables and commentaries adds appreciably to the value of the book as a work of nautical reference.

In its 60 years of existence *Jane* has had five editors, the first, of course, being Fred T. Jane himself, the founder, who personally directed its editing until his death in 1916. His immediate successor was Maurice Prendergast, who was joined in 1919 by Dr. Oscar Parkes. When Prendergast had to relinquish his task because of failing eyesight, the late Francis McMurtrie began his long connection with the office, which lasted until his death in 1949, by which time he had been sole editor for 15 years, Dr. Parkes having retired in 1934. McMurtrie was succeeded by the present editor, Mr. Raymond V. B. Blackman, to whom has fallen the task of recording more numerous and fundamental changes in the world's navies than would have seemed possible even when he took office; and his foreword to the present volume shows vividly that still more extensive changes are to be expected in the near future.

The changes in the contents of the book, apart from the additional features already indicated, have been gradual for the most part, and not usually obvious except by comparison with issues, say, five years or more different in date. One such change has been in the means of identifying individual ships. For many years the pages of *Jane* bristled with little sketches and notes of minor details of rig or equipment which would serve to distinguish between what were nominally sister ships; now, most of these have become unnecessary, as reference to the list of pennant numbers does all that is required. Tabulated particulars of naval guns have virtually disappeared, largely as a result of a general disposition to " caginess " in the world's Admiralties, developed during the first World War and never really relaxed. Indeed, many of the additional notes about particular ships and classes, which have gradually crept back after the complete embargo of the war years, bear all too clearly the stamp of offices of " naval information " rather than those of the technical and design departments. This is no doubt inevitable, but it is regrettable. Mr. Blackman has countered the tendency to some extent by keeping his eye on the proceedings of technical institutions; though these, too, are now much affected by the dead hand of alleged " security."

In the circumstances, he has done remarkably well to find enough material about the Russian Navy to fill 38 pages, and to include in them a number of really excellent photographs of recent cruisers, destroyers and even submarines.

As *Jane* is, for practical purposes, almost the only source of information about the fleets of the Soviet Union, it is of interest to summarise the conclusions reached about them, even though these are qualified with many " ifs " and " buts." It is stated that the Russian submarine fleet now numbers more than 475 vessels, many of them new long-range craft, and the estimate is made that, in each of the years 1958 and 1959, 75 to 85 new submarines will be commissioned. Russia now has 32 cruisers, 180 destroyers, 300 frigates and escort vessels, 1,000 minesweepers, and 500 motor torpedo-boats and coastal craft; but in new construction the trend is not so much towards more cruisers as towards fast ocean-going destroyers and frigates.

It is interesting to speculate on the extent to which Russian naval architecture may be based upon German prototypes, though the speculation could easily be pressed too far. There is certainly an appearance of clean efficiency about the latest Soviet surface craft that is very far removed from the Russian standards of 20 years ago.

NEW BOOKS

A Guide to the Aircraft Maintenance Engineers' Licence Examinations. *The Society of Licensed Aircraft Engineers, 1 High-street, Maidenhead, Berks.* (10*s.* 6*d.*)

Licensed aircraft maintenance engineers are those authorised by the Air Registration Board to make certification, on behalf of the Minister of Transport and Civil Aviation, in respect of aircraft maintenance, overhaul, modification and repair, according to the terms of their licences. The purpose of the present booklet is to summarise and explain the requirements governing the licence examinations conducted by the A.R.B. (covering aeroplanes, engines, equipment and instruments, but not radio) to give guidance on the form of the examinations, and to assist applicants in interpreting the examination syllabus. Categories of licence are detailed, duties of engineers licensed in various categories are described, and the procedure for granting, extending and renewing licences is discussed. Thirty pages are devoted to specimen examination papers for every licensing category, and complete syllabuses are given. Finally, advice on how to prepare for and tackle the examinations is provided, in considerable detail.

Thermodynamics for Chemical Engineers. By HAROLD C. WEBER and HERMAN P. MEISSNER. Second edition. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (8.50 dols.); and *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (68*s.*)

First published in 1939, the work attempts to cover thermodynamics from the viewpoint of both the engineer and the physical chemist. The second edition includes many solved illustrated examples which are lacking in the earlier issue, and detailed descriptive chapters on power cycles, engines and turbines, and refrigeration. Elementary fluid flow is treated fairly thoroughly. The book is based on material used in recent undergraduate and first graduate courses at the Massachusetts Institute of Technology, and the presentation aims at developing judgment and resourcefulness in the student. Problems are set at the end of each chapter, and tables of conversion factors and thermodynamic properties of materials are given in an appendix.

Prospection Électrique. By PIERRE LASFARGUES. *Masson & Cie., 120 Boulevard Saint-Germain, Paris* (VIe). (3,000 francs.)

The first volume of a series of manuals on geophysical prospecting, published under the direction of Mr. Jean Goguel, has now made its appearance. It is devoted to continuous-current electrical prospecting methods. It is divided up into five main sections, the first of which deals with potential mapping. The second is concerned with earth resistivity apparatus and methods, and the third with the potential drop ratio method. The fourth section relates to spontaneous polarisation technique, and the fifth to induced polarisation apparatus and methods.

COMING DOWN TO EARTH

Laboratory Testing in Soil Engineering. By T. N. W. AKROYD. *Soil Mechanics Limited, 65 Old Church-street, London, S.W.3.* (35*s.*)

A text-book on soil mechanics usually gives an indication of the type of tests which can be made to measure various properties of a soil without giving elaborate detail. On the other hand, the worker in a soil mechanics laboratory carries out tests by methods which have become established in his laboratory. Originally, the method may have been taken from a paper given by the man who developed the test, or from a text-book, or it may have been developed within the laboratory. It is usual to find small differences in the exact details of carrying out even the more common tests in different laboratories, and sometimes a laboratory will have its own methods written down to help new staff.

Developments in soil mechanics testing techniques are still occurring sufficiently rapidly for it to be unwise to attempt to standardise all of them. Some, however, are well established and have been standardised by A.S.T.M.[1] and B.S.I.[2] In 1950, W. S. Housel wrote a laboratory manual describing 37 soil tests in detail.[3] Many of the methods were those used by his own laboratory at the University of Michigan, and all of them related to American practice. Now several of the tests are out-moded, but the presentation was good, and full details of the test method and dimensioned drawings of apparatus were given.

A year later, in 1951, T. W. Lambe compiled *Soil Testing for Engineers*,[4] a work which he claimed was not a manual but a text-book for the teaching of soil testing. He described about 16 tests, mainly as carried out in his own laboratory at M.I.T., and gave quite a lot of background information relating to the theory and application of test results, but was careful to avoid detailed step-by-step descriptions of the tests. In this way the book fell between the stools of a text-book and a manual of testing instructions.

Mr. Akroyd's new book has a similarity to Lambe's work and it is rather difficult to decide what readers he had in mind. He describes about 50 soil tests, mainly as performed at his own laboratory, that of Soil Mechanics Limited, which was the first and is now probably the best-equipped commercial soil mechanics laboratory in Great Britain. To those in the field, the book forms an interesting record of the testing procedures used by that laboratory, though some of their latest methods may have been purposefully omitted. Mr. Akroyd claims that the purpose of the book is to describe the more common tests carried out in an investigation of the physical properties of a soil, but it would be difficult to carry out many of the tests described without including much of the worker's own methods to fill in the undefined finer points.

The appearance of the book is very pleasant; it is printed on good quality quarto paper with readable type, and the diagrams and photographs are very clear. Several of the photographs show apparatus being used, which is so much more informative than views of the apparatus by itself. Many of the line diagrams, which are barely referred to, could have been better used to shorten and clarify complicated descriptions. Unfortunately, too, there is a shortage of dimensioned drawings of apparatus, and it would be difficult to specify apparatus for many of the tests without additional information.

REFERENCES

[1] A.S.T.M., Specifications D422, D423, D424, etc.
[2] B.S.I., B.S.1377, B.S.1796, and B.S.1924.
[3] W. S. Housel, *Applied Soil Mechanics: Laboratory Manual of Soil Testing Procedures*, University of Michigan, Civil Engineering Dept (1950).
[4] T. W. Lambe, *Soil Testing for Engineers*, John Wiley & Sons Inc., New York (1951).

Design

RAISING HEAT TRANSFER IN SEAWATER EVAPORATORS

The Chemical Engineering Division of the Admiralty Materials Laboratory, Holton Heath, Poole, has carried out research on seawater evaporation for a considerable number of years. In the past, effort has been devoted to the prevention or modification of scale in evaporators together with the development of suitable anti-foams to increase the utilisation of coil area of existing plant. This research has resulted in the use of such materials as Admiralty evaporator compound (with anti-foam incorporated) and ferric chloride as feedwater treatments in seawater evaporators. Admiralty evaporator compound manufactured by the Geigy Company Limited was used in S.S. "Gothic" during the Royal Commonwealth Tour of 1954, and allowed continued operation of evaporators at a high level of output. Similar results were obtained during trials in F.F. "Balaena" with the co-operation of the Hector Whaling Company Limited.

Over the past 2½ years, in conjunction with the Central Technical Institute of the Netherlands Organisation for Applied Scientific Research (T.N.O., Holland), more emphasis has been placed on the physical characteristics concerned with seawater evaporation, one of which was the value of the overall heat-transfer coefficient, U. High values of U have been obtained by causing the heating steam to condense on the heating surface as discrete drops instead of the more usual film, by the use of suitable dropwise promoters. For example, values for copper as high as 3,000 B.Th.U. per hour per sq. ft. per deg. F. have been obtained in an evaporator working under boiling conditions at atmospheric pressure, and 1,600 B.Th.U. per hour per sq. ft. per deg. F. in a flash evaporator under non-boiling conditions, as compared with less than 1,000 B.Th.U. per hour per sq. ft. per deg. F. in conventional seawater evaporators. It can be seen that a more compact and less expensive evaporator can be designed as a result of this development.

Small pilot-plant evaporators, operating under boiling conditions with natural and forced circulation, and under non-boiling conditions, have been built and operated with natural seawater under conditions of high overall heat-transfer coefficient. High percentages of calcium sulphate scale were eliminated by the use of flow rates high enough to prevent a concentrated film forming at the heating surface. Attempts to use high heat fluxes in conventional evaporators even with small temperature differences may lead to excessive deposition of calcium sulphate. In the case of the alkaline scales (calcium carbonates and magnesium hydroxide), it was found that, under boiling conditions, the higher the initial overall heat-transfer coefficient, the greater was the amount of fresh water produced before scale needed to be removed. Under non-boiling conditions, after an initial fall, a nearly constant value of U far higher than is usual for flash evaporators was obtained.

No chemical feed treatments were used in any of the trials and in the case of the flash evaporator it was demonstrated that the small amount of scale formed could be removed without the use of chemicals and without shutting down the plant.

Through the courtesy of the Department of the Engineer-in-Chief of the Fleet it has been possible to carry out tests with dropwise promoters on an evaporator with submerged heating elements of new design, and a rated output of 25 tons per day. Although it was not feasible to increase the output materially above 25 tons per day due to limiting factors such as condenser capacity and size of pumps, it was shown that by application of dropwise promoters an output of 19½ tons per day could be obtained using only half the heating elements, but under otherwise normal operating conditions. Without dropwise promoters the output under these conditions was 13 tons per day. The heating elements used in this trial were manufactured from Monel metal which has a thermal conductivity of only 180 B.Th.U. per in. per hr. per sq. ft. (compared with copper at 2,640 B.Th.U. per in. per hr. per sq. ft.). An even greater improvement would be expected, therefore, with elements of a material of greater thermal conductivity. Details of the more recent work at the Admiralty Materials Laboratory are in course of publication.

While some improvement can be achieved in the performance of existing evaporators by raising the overall heat-transfer coefficient, a greater advantage is likely to be gained from improved designs. Future work at the Admiralty Materials Laboratory is being directed towards this end.

KEEPING THE DECKS CLEAR OF FUNNEL SMOKE

If a naval architect is to predict, solely from a ship's drawings, whether that ship is likely to be free from smoke trouble, he needs to have data from which he can estimate (*a*) the probable height of the turbulent boundary—the upper boundary of the zone of turbulent air flow over the ship, and (*b*) how much his particular funnel should project above the boundary to ensure that the smoke shall not be drawn down into the turbulent zone. Both these factors have been the subject of investigations sponsored by the British Shipbuilding Research Association; work on problems of type (*b*) is still in progress. Data on the probable height of the turbulent boundary has recently been presented in a lecture given before the Institute of Marine Engineers in London on "Superstructure Design in Relation to the Descent of Funnel Smoke," by Mr. E. Ower, director of British Thermostat Company, Limited, and previously head of B.S.R.A.'s intelligence department, and Mr. A. D. Third, research director of Thermotank Limited. In the written paper are presented diagrams and formulae from which the height of the turbulence boundary can be calculated.

This information was obtained entirely from wind tunnel tests, but comparative tests carried out at sea demonstrated that such wind tunnel tests accurately reproduce full-scale conditions. These tests also are described in the paper. Finally, the authors deal briefly with the problem of smuts—essentially different from that of smoke.

Broadly summarising the features revealed by the wind tunnel tests, the turbulence boundary can be appreciably lowered by rounding the sharp edges of the superstructure, particularly in elevation. The effect of rounding in plan is also appreciable provided that the whole front is rounded and not only the sharp vertical edges. Sloping or stepped-back fronts produce a worthwhile improvement if the angle of slope or set-back is less than 60 deg. to the horizontal. All these advantages tend to be lost, however, if the length of the superstructure is less than the beam.

Measures that may cure the smoke problem will not necessarily eliminate the falling on to the deck of smuts, which are much heavier than smoke particles. A possible method for preventing the ejection of smuts from the funnel is to include in the uptake a vertical section in which the gas velocity is reduced to a value less than the natural rate of fall of the smuts in still air. If the velocity in this section does not exceed 10 ft. per sec. and the velocity upstream of the expansion is not greater than 45 ft. per sec., the total height of the expanded section should be about 12 ft.

RADAR AND RADIOTELEPHONY ON "MAURETANIA"

While the liner "Mauretania" has been undergoing a major refit at Liverpool, technicians from the Liverpool depot of the Marconi International Marine Communication Company, Limited, Chelmsford, Essex, have installed new high-power transmitters and radar equipment incorporating a radar track indicator. Two new "Globespan" transmitters with "Atalanta" and CR 150 receivers will operate a radiotelegraph service on medium and high frequencies, and provide radiotelephone facilities in the intermediate and high-frequency marine bands. Privacy of radiotelephone correspondence is ensured by the provision of speech inversion equipment. A "Reliance" emergency transmitter has been fitted, and two of the Class "A" motor lifeboats are equipped with permanent "Salvare" wireless installations.

One of the "Oceanspan" transmitters with which the liner was fitted has been retained for auxiliary use, but the TGY radiotelephone equipment which was installed on the bridge has been removed and in its place a remote speaking point is provided from one of the high-power "Globespan" transmitters. In addition, a "Nautilus" v.h.f. transmitter/receiver will enable the Mauretania to use the Southampton Harbour Board's new Port Operation and Information Service, and she did, in fact, take part in the inaugural ceremonies when she sailed from Southampton on January 17.

The "Nautilus" transmitter/receiver is a combined simplex-duplex v.h.f. radiotelephone equipment designed primarily to enable ships to communicate on the international calling and inter-ship frequencies, and on port control and public correspondence channels. It provides for rapid selection of any one of up to 15 preselected crystal controlled channels in the 154 to 165 Mc/s band. The design conforms with the technical characteristics for frequency-modulated v.h.f. marine equipments recommended at The Hague Conference in January, 1957.

The Marconi Marine "Radiolocator II" radar equipment which has been in service for some years will be retained for the present; but new "Radiolocator IV" equipment, incorporating a 15 in. display unit and a radar track indicator, has now been installed. The track indicator enables the navigator to select, at the turn of a switch, the type of radar display best suited to his immediate needs—north stabilised, "ship's head up" or track indication on which the true course and speed of all targets can be seen at a glance.

LOCAL-SERVICE VISCOUNT

A prospective new member of the Viscount family of air liners has been announced recently by Vickers-Armstrongs (Aircraft) Limited, Weybridge, Surrey—the Local-Service Viscount, developed specifically for local-service operation on the North American continent. The requirements for an aircraft of this type are the ability to make a series of short flights, operating from secondary airfields with full payload, averaging,

Continuing **Design**

say, 100 miles or less, without refuelling and ground-servicing at transit stops and with a minimum of traffic handling. It must be capable of cruising at low altitude at maximum cruising speed—a condition which is not within the compass of most of the coming generation of turbine-powered aircraft, which generally are not stressed for high-speed operation below altitudes of about 20,000 ft.

To meet these requirements, Vickers-Armstrongs are offering the Local-Service Viscount with a well-proved fuselage structure, systems and power plant. The wing structure will be strengthened to permit high-speed operation at low altitude. The fuselage is similar to that of the Viscount 700 series, but with redesigned cabin layout to provide seating capacities for from 54 to 65 passengers; and operating at a lower cabin pressure differential—4·5 lb. per sq. in. instead of 6·5 lb. per sq. in.—since the aircraft will not be expected to fly at high altitude. This change in pressure differential, it is stated, more than compensates for the increased number of pressurisation cycles completed during the life of the aircraft.

The engines chosen are the earlier 1,540 h.p. Rolls-Royce Dart 506 propeller turbines, which have accumulated a greater background of experience than have the later more powerful variants. These engines, too, are lighter and less costly, and they do not make use of water/methanol injection, an unnecessary complication for this type of operation.

Quick turn-round features built into the aircraft will include folding passenger steps carried inside the forward entrance door, propeller brakes on the two port and starboard inner engines to speed-up unloading operations, and provision for additional batteries for internal starting of the engines.

The performance of the Local-Service Viscount is as follows: at maximum weight, 61,500 lb., under international standard atmospheric conditions, the take-off distance to clear 50 ft. is 4,850 ft. The maximum cruising speed is 320 m.p.h.; and the range, with full payload (11,620 lb.), plus reserves for 115 mile diversion and 45 min. " holding " at 5,000 ft., is 800 miles. In the high-density version (60-65 passengers), the freight hold capacity is 174 cub. ft.; in the standard version (54-59 passengers), additional freight capacity is available giving a total of 399 cub. ft. The dimensions of the aircraft are: span, 93 ft. 11 in.; length, 81 ft. 10 in.; and height, 26 ft. 9 in.

Deliveries can be made by the middle of next year.

COMPUTER FOR HEAVY ELECTRICAL DESIGN

C. A. Parsons and Company, Limited, Newcastle-upon-Tyne, have ordered a Ferranti Pegasus digital computer costing about £50,000 to be installed at their Heaton works. Delivery will be completed in about twelve months. The computer will be used for the design of heavy electrical equipment including steam and gas-turbo generators, and transformers, and for switchgear produced by their associated company, A. Reyrolle and Company, Limited, Hebburn-on-Tyne.

The Nuclear Power Plant Company, Limited, and member companies of that consortium will also use the machine for nuclear engineering calculations and problems related to the design of reactors and associated equipment. Optical calculations on behalf of Sir Howard Grubb Parsons Limited will also be carried out on the machine. This is the third Pegasus computer to be ordered in the engineering industry in addition to six for the aircraft industry. King's College, Newcastle, a part of the University of Durham, already has one of these machines and the present order is the second computer of this type to be installed in Newcastle.

Production

CRACKING IN POWDER COMPACTS

By W. M. Long, B.SC., *of the Coal Research Establishment, National Coal Board*

Tablets, briquettes and similar compacts made under pressure in moulds and dies often contain cracks, especially around the edges of the surfaces which were in contact with the ram and with the base of the die during pressing. The dotted lines in Fig. 1 show typical positions of these cracks in a simple cylindrical compact. The rectangle A A B B represents a cross-section of the compact in a plane containing the axis of the cylinder, this axis being parallel to the lines A B, and A A represents the top face of the compact, the face on which the pressure has been applied. The cracks may not extend across the full width of the compact, and may appear at one end only. When cracking is severe, the top or bottom regions, or both, may fall away from the main body of the compact. In tablet-making, this is sometimes known as " capping."

Various explanations of this phenomenon have been put forward: a number are listed by Goetzel.[1] The following are examples: (i) expansion of air trapped in the compact; (ii) elastic expansion of the compact as it is ejected from the die: in the intermediate stages of ejection the top is free to expand while the bottom is still constrained by the die, and the resulting stress differences may produce a series of laminar fractures, starting with one of the type shown in Fig. 1; (iii) differential expansion of the compact on release: the compact is not uniform, and when it is released from the die some regions may tend to expand more than others; strains would be set up which might lead to cracking. However, the history of formation of the compact suggests another cause.

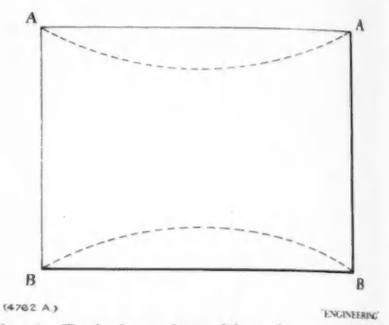


Fig. 1 Typical crack positions in a cylindrical compact.

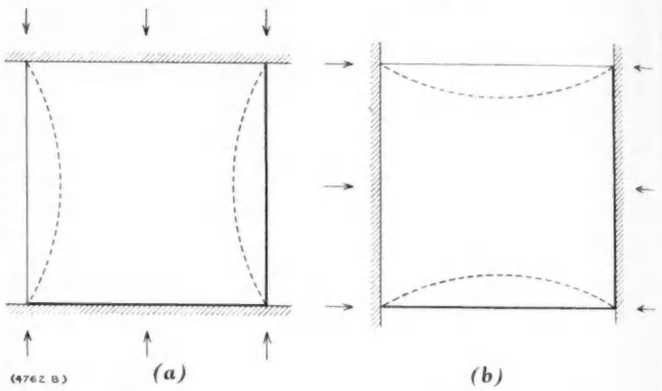


Fig. 2 Forces and typical surfaces of failure; (*a*) in a compression test; (*b*) for a compact constrained in a die.

Consider a bed of powder being formed into a cylindrical compact in a die. As the ram exerts pressure on the powder, the powder in turn exerts pressure on the side walls of the die. Now imagine the powder bed replaced (i) by a true solid of the same external dimensions, formed from the same material as the powder, and (ii) by a liquid. In the first case, the pressure exerted on the walls would be determined by the elastic properties of the solid material: were the solid isotropic and perfectly elastic in behaviour, and the die perfectly rigid, the pressure on the walls would be equal to Poisson's ratio times the ram pressure. In the second case, the pressure on the walls would be equal to the ram pressure. Now the pressure-transmission characteristics of the powder bed are not the same as those of the solid: in a loose powder, the particles are not firmly attached to one another, and inter-particle slip can occur. This mobility of the particles confers on the powder some of the properties of a liquid. The result is that the pressure exerted by the powder bed on the side walls of the die is greater than that which would be exerted by the true solid, though less than the hydrostatic pressure which would be exerted by a liquid. The pressure of the powder on the walls in fact may be regarded as the sum of two components, one being an " elastic " component deriving from the elastic properties of the solid material, and the other a " plastic " component deriving from the flow properties of the powder.

After the ram pressure has reached its maximum and been released, the elastic component of the wall pressures disappears; but the plastic component does not, for the powder has become a compact, and the particles tend to retain the configuration reached at the point of maximum pressure. Under these conditions, the particle flow is not reversed.

The result is that when the ram is withdrawn, the powder, formed into a compact, is still exerting a pressure on the die walls; and the die walls, by reaction, are exerting a pressure on the compact. It is this residual pressure which causes the compact to remain firmly held in the die when the ram is withdrawn.

It seems very likely, also, that the residual pressure is the principal cause of cracking of the type described above. Compare the familiar situation in which a cylindrical test-piece is compressed in a testing machine by pressure applied on its end faces, Fig. 2 (*a*), with the situation in which a newly formed cylindrical compact is compressed by the walls of its die, Fig. 2 (*b*): in these diagrams, the arrows represent the directions of the applied forces and the dotted lines the surfaces of failure. The comparison is striking: taking experience with compression tests as a guide, the cracks in the compact occur in precisely the positions which are to be expected, on the assumption that they are caused by the wall pressures. The difference between the two cases is that in one the pressure is applied on the end faces of the cylinder and in the other

on its curved face, the positions of the crack surfaces varying accordingly.

The magnitude of the residual wall pressures will presumably vary with the flow properties of the powder from which the compact is formed: experiments with powdered coal give a mean residual wall pressure of between 10 and 20 per cent. of the maximum ram pressure, and for metal powders these figures might be increased. The residual pressures are therefore quite high: high enough, it would seem, to cause considerable damage in the compact. (Tensile tests on specimens cut from coal compacts give a stress at failure the magnitude of which is only about 1 per cent. of that of the maximum ram pressure.) It is not to be expected, however, that the residual wall pressures will be uniform over the curved surface of the compact, for the ram pressure is not transmitted uniformly through the compact. For the same reason, the compact itself is not uniform in composition and in strength. These two factors, the non-uniformity of the residual wall pressures and the non-uniformity of the compact, might explain the observed variations in the cracking phenomena—the appearance of cracks at one end only, for example.

A full analysis of the stresses in the compact after removal of the ram would doubtless throw more light on the phenomenon, but the possibility of obtaining such an analysis seems small. In a detailed theoretical analysis of the compression test, Filon[2] has shown that the positions of the surfaces of failure are determined by stress and strain concentrations produced by friction between the pressure plates and the test specimen: we may suppose that the same processes operate in a die, and that friction between the compact and the die wall produces stress concentrations in the regions in which the cracks appear. It is therefore to be expected that lubrication of the die walls, by reduction of this friction, would reduce the stress concentrations, and therefore help to prevent cracking: and Goetzel[1] confirms that this is so. Another obvious prediction is that removal of the compact under suitably controlled axial pressure should prevent cracking. Complete relief of the axial pressure before extraction, since it is not accompanied by complete relief of the wall pressure, exposes the compact to a large stress difference which is the primary cause of cracking: if both pressures are relieved simultaneously, this situation would be avoided and cracking should be prevented. This remedy also is known to be effective.[1, 3]

The appearance of a series of laminar fractures (cracks running around the curved face of the compact) as the compact leaves the die would be explained, on the present hypothesis, in the following manner. The first cracks appear when the ram is released, the compact remaining in the die. These cracks are produced by the stress concentrations previously mentioned, which run into the interior of the compact from the edges of the area over which the wall pressures act, that is, the area of contact between the die wall and the compact. As the compact emerges from the die, this area shrinks, and the stress concentrations, following the shrinkage, move down the compact towards the end which is last to leave the die. In doing so, they produce a series of cracks, each crack providing a temporary relief of stress.

It is not suggested that the mechanism described here is the only one involved in the phenomenon of cracking: the evidence that entrapped air plays some part is fairly strong. It does seem probable, however, that the residual wall pressures are the principal cause: these pressures are large, and the cracks occur in the positions which would be expected, on the hypothesis.

The ideas put forward in this paper arose from work forming part of the research programme of the Scientific Department of the National Coal Board. The views expressed are those of the author, and not necessarily those of the Board.

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[1] "Treatise on Powder Metallurgy," by C. G. Goetzel, pages 303, 304. Interscience Publishers, Inc., New York (1949).

[2] L. N. G. Filon, *Phil. Trans. A*, 198, pages 147-233 (1902).

[3] E. Fernholtz. U.S. Patent No. 1,265,441 (1918).

INGOT PLANT BUILT IN 20 MONTHS

Aluminium at Baie Comeau

Immediately before Christmas the first metal was poured at the new aluminium smelter of the Canadian-British Aluminium Company. This marked the end of the first of four production stages of this £50 million plant which is to have an eventual annual capacity of 160,000 tons of virgin ingot. The company is the joint subsidiary of the British Aluminium Company in this country and the Quebec North Shore Paper Company in Canada. The smelter is at Baie Comeau.

One of the outstanding features of the construction has been the speed of the operation. Serious negotiations between the two companies began in the summer of 1955 and only 20 months have elapsed from the clearing of the site to the pouring of the first metal. The enterprise has involved building access roads, constructing a wharf built to berth three 10,000 ton ships, a 300 ft. long belt conveyor for raw materials and a major housing development scheme, in addition to the smelter itself. The general contractors of the smelter are Anglin-Atlas Limited, which is a joint undertaking of two well known Montreal contracting concerns and the wharf was built by Sir Robert McAlpine and Sons (Canada) Limited. Among the larger United Kingdom contractors were Redpath, Brown for the steelwork, the English Electric Company for switchgear and transformers, British Thomson-Houston for rectifier equipment and the Cement Marketing Board for the cement. Much of the success for the short period of construction must go to the quality of the materials and servicing given by the United Kingdom and Canadian contractors, the intelligent use of progress chasers and the standard of administration in Canada and in London.

CONTINUOUS STOCK RECORD

To facilitate the keeping of stock records, or for any other purpose in a factory or stores where a record of numbers is required, K. Bisset and Company, Limited, 145 Grand Buildings, Trafalgar-square, London, W.C.2, have brought out a simple machine called the "Stoktrol." It is self-contained, in a metal case about 17½ in. by 11 in., and can be hung or fixed in any convenient position. On the front of the case are three oval windows, and three dials, similar in appearance to those used on automatic telephones.

The dials represent units, tens and hundreds, and as stock is issued the number is "dialled" by a stylus on the appropriate dials. This number is subtracted automatically from the total, and the result is indicated by figures which appear in the windows. Similarly, instead of working against a figure representing items in stock, the machine could be used to show progress towards a chosen numerical target. This would be set, and as production proceeded, the numbers would be dialled; the windows would then show the balance required at any time.

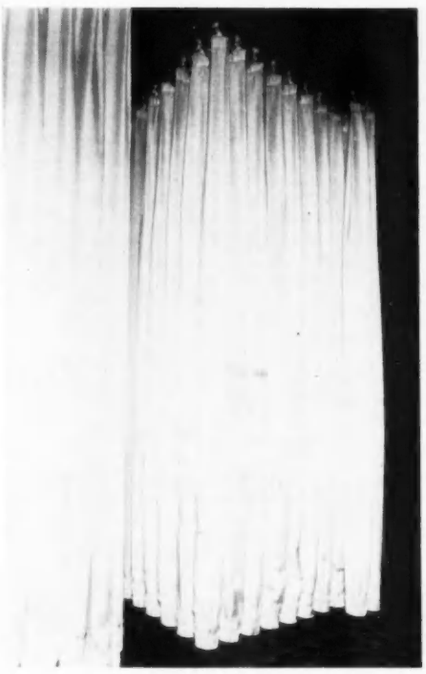
The machine has a capacity of 1,000 but models can be produced to deal with larger numbers if required. It can also be supplied to add instead of subtract.

FILTERING THROUGH FIBREGLASS

In the manufacture of carbon black it is necessary to filter large volumes of gas. The presence of gases which can cause corrosion make it desirable to keep the temperature of the filters well above the dew-point, which is around 160 deg. F. In addition, the filter designers have to take into account the fact that the dust loading is heavy, prevent excessive back-pressure across the filter, and produce a plant which will operate continuously for long periods. It is also very important, of course, to prevent the escape of carbon black into the atmosphere, both because it is a valuable product and from the nuisance viewpoint.

To meet these requirements, Philblack, Limited, Avonmouth, have installed at their extended carbon black plant two dust collectors made by Tilghman's, Limited, Broadheath, Altrincham, Cheshire, in which the filtering material is a fabric woven from Fibreglass. This fabric is corrosion resistant, and will withstand temperatures of 400 to 500 deg. F.

The dust collectors each comprise six separate compartments in two lines of three, back to back. Each bank of three compartments discharges into a common dust hopper. Special inlet ducts discharge the dust-laden gases in a downward direction into the hoppers, so reducing considerably the dust loading of the gas presented to the filter tubes. The gas is then drawn up vertically through openings in cast iron tube plates and so into the open ends of the Fibreglass fabric filter tubes. After the gas has deposited its dust burden on the insides of the fabric tubes it passes in its cleaned state to a common plenum chamber and is discharged by fan to the stack and so to atmosphere.



Fibreglass fabric tubes are used for filtering gases in the manufacture of carbon black. They are cleaned by isolating a chamber and feeding clean gas in the opposite direction.

Removal of the filtered carbon black from the insides of the fabric tubes is achieved by isolating one compartment from the dirty gas stream and then passing a controlled volume of clean gas through it in the opposite direction. This causes a partial collapse of the tubes, so breaking the layer of caked dust, which falls down the tubes into the hopper below. Provision is made for shaking the tubes mechanically while they are deflated, should conditions require it.

Engineering at Home

BUILDING COLOUR PATTERNS

101 colours form the range of British Standard 2660. It is designed for architects and other paint users who wish to pick out chromatic harmonies quickly and easily. Ten cards carry the range of colour patches, which are grouped systematically. A number identifies each patch; no eccentric soubriquet is allowed to mar the clarity of the standard. 0-001 denotes a yellow and the numeration continues through the various hues in the painters' spectrum until a dark grey becomes 9-101.

B.S.2660, " Colours for Building and Decorative Paints," is now used fairly widely. However, since the range was published, in 1956, it has been found that users tend to ask certain questions about it; so the Building Research Station, Garston, Hertfordshire, decided it would be helpful to collect together typical questions and the appropriate answers. The resulting catechism is set out in Building Research Station Digest 101.

The digest contains 11 questions. They range from the broad " On what principles were the colours chosen?" to the specific " Why are there blanks between colours on some of the cards in the B.S.?"; from the tentatively co-operative " Can B.S.2660 be used to tidy up the colour ranges of other materials than paint?" to the mildly reproachful " Is not the number of greys on card 9 rather excessive?" All the answers are courteous and informative.

The cards were envisaged as a design tool. In the presentation, first importance is given to making the categories of the colours explicit. Each card has square patches of colour spaced evenly up its sides; card 0 carries the strong colours and card 9 the greys; cards 1 to 9 each represent a particular hue, with greyish colours on their left and fairly strong colours on their right. Usually colours grow darker as the bottom of the card is approached. " Strong colours "—those with the highest degree of colour saturation —form the largest class. There are 14 of them. This number decided the sizes of the card and the colour patch. As the other cards have fewer than 14 colours, blank spaces result. But the blanks are valuable as they make it easier to line up colours of the same " value " at the same horizontal level on each card.

" Value " is a term used in the Munsell system of colour classification. The system uses three co-ordinates—value, chroma, and hue—to identify a colour. The co-ordinates define a position in colour space. In the British Standard the colours conform for the most part to 9 different values, 9 hue groups, and 4 grades of chroma. In the Munsell system the value relates to the lightness or darkness of a colour and is quoted as ranging from 0 to 10. Black is 0; white is 10. A rough estimate of the reflectance, as a percentage, is given by the formula $V(V - 1)$, where V is the value. Hue distinguishes red from blue, green from yellow, etc. It is denoted by a letter and a prefixing number. The letter might be R, showing that the colour is in the red portion of the hue circle; the number adds precision. If, for example, the number prefixing R is greater than 5, the colour inclines to the yellow red, if it is less than 5 the colour inclines to the red purple; and so on round the hue circle. Chroma indicates the strength of colour and is based on a scale from neutral grey towards full strength at any given value level. A complete reference such as 7·5 R 9/2 means a pale pink: the hue of 7·5 R denotes red inclined towards yellow red; the value 9 denotes a very light colour; the chroma 2 shows that the strength of the colour is low. The four main categories of card—from grey to strong—were identified by limits expressed by chroma references. On the cards the nearest simple Munsell references are given for each colour, as an aid to designers.

Other principles governed the layout of the range. Two were that it should contain as many pleasant and harmonious combinations of colour as possible and that the limitations of paint pigments were to be accepted in the detailed choice of colour. The first was met partly by the decisive spacing of the colours into their various categories. This helped to avoid the weak effects that occur when adjacent colours neither harmonise nor contrast.

Limitation of pigments are met in card 0. The card groups together the strongest and brightest samples of each hue, yet the average strength of those on the right—green-yellows, green, blue-green, blue, and purple—is lower than that of those on the left—yellows, orange, and reds. The original proposals gave approximately equal strength to each of these colours but the paint industry asked for reductions in the strength of the right-hand ones to ensure a reasonable standard of light fastness. Even so, three of the colours are not recommended for exterior use. Card 0 contains some colours that are, in fact, rather weak.

The range was intended to be a self-sufficient unit. Extension of the range by mixing was not visualised. To ask architects to conform to a limited set of colours may seem unreasonable when artists have unlimited freedom. But artists use paint to create patterns and textures and, perhaps, illusions of form and lighting. In contrast the architect has real variations in lighting, form, pattern and texture, to which he adds his colours. When the many other coloured materials at the architect's disposal are taken into account, it appears desirable to accept a discipline in the colours of the paints, rather than search for a way of extending the range.

MAKING FURNITURE SUFFER

The British Standards Institution publish standards for domestic furniture. Performance tests rather than structural specifications constitute the main criteria. The tests, devised basically by the Furniture Development Council, together with specifications of the quality of raw materials are looked on as the best way of ensuring strength and durability. A similar standard for school furniture is to be published soon.

In the development of performance tests for furniture it is important that the test should be closely related to the function of the article and to the loads it bears in normal use. It is for this reason that domestic furniture and school furniture require different standards. The loads borne by school chairs, for example, are generally of a different nature to those borne by domestic dining chairs. The way in which the types and magnitudes of the loads vary is outlined in *Technical Bulletin* 38, published last month by the Furniture Development Council.

One type of loading that the normal dining chair has to withstand is a system of forces tending to act diagonally from the seat of the chair to its back legs. The stress is most severe when the chair sitter leans backward heavily, tilting the front legs of the chair off the ground; a distributed load then acts at an angle to the surface of the seat. In order that the magnitude of the forces should be investigated, a stoutly-built dining chair of orthodox design was fitted with micrometer dial gauges at its main rail joints. Thus the angular deformation of the joints under working conditions could be measured. Different people of various proportions then sat in the chair and tilted it backwards. The dial-gauge readings obtained were roughly proportional to the weight of the chair sitter, and it was discovered that a similar load distribution between the various joints could be simulated with a testing machine that applied a load directed from the front of the seat to the foot of the back legs. Somewhat arbitrarily it was decided that the chair should withstand repeated loads equivalent to that inflicted when a sitting person weighing 18 stone 4 lb. swung back on to the two rear chair legs. It was found that the same stress was put on the general structure of the chair by a diagonal load of 175 lb. This was adopted for testing purposes.

When the complete set of tests for domestic furniture had been drawn up, the Furniture Development Council was approached by the Minister of Education to devise similar tests for school furniture. It was soon apparent, say the Council, that the tests for domestic dining chairs were not adequate for the testing of schoolroom chairs. It was decided that the problem should be investigated from the beginning, not that existing procedures should be modified. This approach led to a completely new set of tests.

Classroom chairs are subject to shock loading, through being dropped and moved about. It is comparatively easy to imitate this form of loading by the use of simple equipment that drops the chair from a known height and known position on to a standard surface. To discover the severity necessary for the test, a shock recording device was fitted to the legs of a number of chairs in schools in the London area. These instruments showed some interesting results. A fairly large number of readings indicated drops of about 12 in. and these were thought to correspond to the normal process of moving the chair about. There were no records of drops of about 16 to 18 in. but there was a further batch of results equivalent to drops of about 24 in. These are suspected to result from the practice of putting the chairs on top of desks when the rooms are being cleaned.

Other tests were devised to simulate other uses. A method of combined diagonal loading and twisting was developed to reproduce the loads occurring when children swing back on the two rear legs of a chair and then twist from side to side.

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